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CONCENTRATION OF THE CONTRAST MEDIUM BILIGRAFIN IN THE BILE AND URINE IN CHOLEGRAPHY

An experimental study in the rabbit

by

Jaan Novek

The literature on cholegraphy apparently contains no conclusive data on the concentration in the bile of varying amounts of Biligrafin and there seems to be no satisfactory work on the capacity of the liver to excrete this contrast medium. LANGECKER, HARWART & JUNKMANN (1953) reported Biligrafin to be excreted rapidly by both the liver and kidneys. Their studies in the rabbit showed that the large dose of 0.72 g/kg bodyweight gave a 2-hour value of 46.0 % of the injected amount of Biligrafin in the bile and 9.1 % in the urine. They found, however, that a similar dose in other rabbit experiments produced a 2-hour value of only 26.4 % in the bile; the 24-hour values also varied. LANGECKER et coll. (1953) stated that a dose of 0.72 g/kg bodyweight produced an excretion of between 73.2 % and 88.0 % in the bile, while OESER & FROMMHOLD (1955) found only 59.8 % of the contrast medium in the bile after one seventh of this dose (0.1 g/kg).

The few investigations reported in the literature (LANGECKER et coll. 1953 and FROMMHOLD 1953) fail to show any relationship between the dose

From the Roentgen Diagnostic Department (Director: Prof. Knut Lindblom), Karolinska Sjukhuset, Stockholm, Sweden. Submitted for publication 25 June 1959.

of Biligrafin administered and the concentration of the contrast medium in the bile, even in one and the same experimental subject. In studies performed by LANGECKER et coll. (1953), for instance, a dose of 0.5 g/kg bodyweight in the dog produced a lower Biligrafin concentration in the bile than 0.1 g/kg of contrast medium. The results published by other authors are not applicable in this connexion, since no exact data as to dosage are included.

LANGECKER et coll. (1953) further reported that in acute fistula experiments Biligrafin exerted a marked choleretic effect and stated: "An der Ratte verursachten 200 mg/kg i.v. an 3 Tieren eine Steigerung der Galle-Tropfenzahl auf 165, und 137, und 200 %." The peak secretion was reached between the first and third hour. The same authors published another series in which two dogs were given 0.057 g/kg bodyweight of Biligrafin leading to: "Steigerung der Galle-Tropfenzahl in 2 Versuchen auf 200 bzw 500 %."

In view of the discrepancy in the experimental results mentioned above, it was thought of interest to investigate the relationship between the amount of contrast material administered and the liver and kidney excretion as well as the concentration in the bile. This relationship was studied in fistula experiments in healthy rabbits under general anaesthesia.

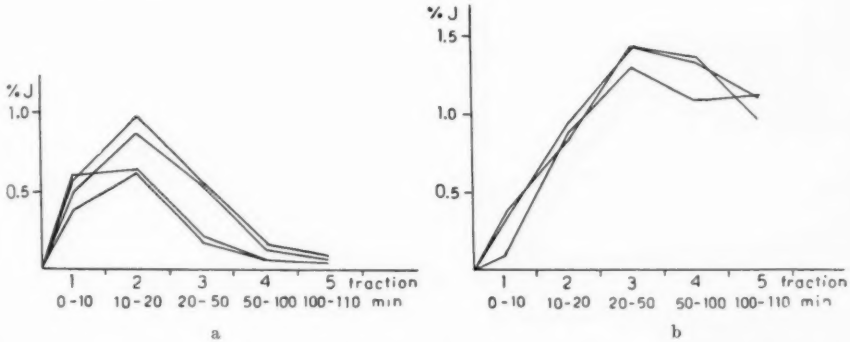
Material and Method

The experimental animals comprised 19 young rabbits (3 male and 16 female), weighing 1.65 to 2.5 kg. Owing to the rhythmic cycle of bile excretion, 15 of the experiments were carried out between 18.00 and 23.00 hours and the remaining 4 experiments at other times. The animals were all anaesthetized with Mebumal, in 15 cases administered intravenously and in the remaining 4 cases intraperitoneally; a total of between 1 and 2 ml Mebumal, according to the weight of the animal, were required. The anaesthesia was kept as superficial as possible, the animals were not subjected to preoperative fasting, nor were they deprived of water.

The Biligrafin was injected into an ear vein at a rapid rate, a large dose taking 90 seconds at the most to administer. Intermittent injection at the commencement of the procedure induced a change in the colour of the ear veins, indicating that the contrast material was in fact entering the veins. The same phenomenon was noted at the end of the injection. Four rabbits were examined with 0.12 g/kg bodyweight, three with 0.32 g, three with 0.62 g, four with 0.94 g, and three with 1.5 g of contrast medium while the remaining two animals were given 2.0 g/kg bodyweight of the preparation.

In the three males the urinary bladder was emptied by catheterization just before starting, and the urine produced in the course of the experiment was collected. In eight of the females the bladder was not emptied by aspiration until the end of the experiment; in this group of rabbits, then, the urine collected was composed of the amount present before the commencement of the experiment as well as that produced during its course.

Laparocentesis, the opening of the duodenum, and the introduction of a polythene tube, 17 cm in length (No. PE 160), into the common bile duct took no more than 3 to 4 minutes. The cystic duct was not tied off, so that the Biligrafin excreted could enter the



Diagrams 1a—b. Dispersion of values in the series given respectively 0.12 g (a), and 1.5 g (b) Biligrafin/kg bodyweight.

gallbladder and the bile in the common duct could not but be mixed with gallbladder bile; consequently, the bile collected from the polythene tube was composed of primary liver bile as well as of gallbladder bile. By keeping a watch on the drip rate, the danger of stagnation was eliminated.

The bile flow during the 10 minutes preceding the injection of the contrast medium was taken as a control sample. When the injection had been completed, the bile produced during the following standard intervals was collected: 0—10, 10—20, 20—50, 50—100, and, respectively, 100—110 min intervals. These periods were selected partly for practical reasons, and partly because of the data on peaks in concentration published by LANGECKER et coll. (1953). When the flow of bile was copious during one of the standard intervals, this was subdivided into part-intervals.

The whole abdomen was opened as quickly as possible at the end of the 100—110 min interval. If a catheter was present in the urinary bladder, the residual bladder contents were expressed manually through it; otherwise, the contents were aspirated, as mentioned earlier. The liver and gallbladder were then excised and the contents of the latter analysed. The removal of the liver led to rapid death of the anaesthetized animals. Finally, the gross appearances of the liver were recorded. The animals in which either the liver or kidneys showed gross changes were excluded from the study and are not reported in the series of 19 rabbits.

Results

The concentration of iodine in the bile was analysed after injection of the different doses of Biligrafin. In the Diagrams 1a—b the dispersion of the values is recorded in different animals after two of the doses given. The means of all the values are compiled in Diagram 2. As will be seen in the latter, the increase in dose from 0.12 to 0.94 g/kg bodyweight led to a rise in the iodine concentration in the bile. After doses of 1.5 and 2.0 g/kg the concentrations were approximately the same as those produced by 0.94 g/kg during the 20—50 and 50—100 min intervals. The highest iodine concentration in the series was thus 1.5 %, representing

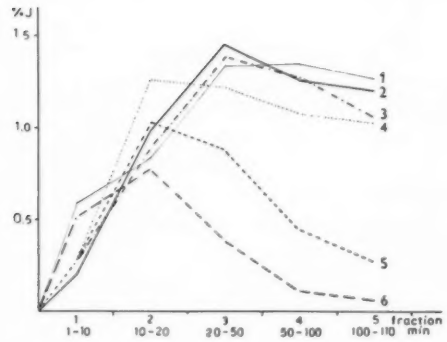


Diagram 2. Mean iodine concentration values in all the experimental series. The differently numbered curves represent doses of Biligrafin/kg bodyweight as follows: 1) 2.0 g, 2) 0.94 g, 3) 1.5 g, 4) 0.62 g, 5) 0.32 g, and 6) 0.12 g.

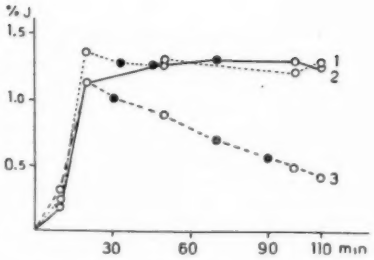


Diagram 3. Iodine concentrations recorded during part-intervals (●) and standard intervals ( ), points representing mean values for relevant intervals. Curves represent Biligrafin/kg bodyweight in the following amounts: 1) 0.62 g, 2) 0.94 g, and 3) 0.32 g.

the mean value for the relevant interval. This does not rule out the possibility that for a short while during that interval the concentration was higher. However, the early intervals after the injection of the contrast medium were relatively short, and the iodine concentrations recorded during the part-intervals were fully compatible with those of the interval as a whole (Diagram 3).

As will also be seen from Diagram 2, the iodine concentrations after a dose of 0.12 g/kg bodyweight were higher in the 0—10 min interval than those recorded after other doses.

The length of time elapsing before the peak concentration of contrast medium was reached was dependent upon the size of the dose. After the injection of 0.12 to 0.62 g/kg the highest iodine concentration was noted during the 10—20 min interval. After a dose of 0.94 to 1.5 g/kg bodyweight the maximum concentration was recorded in the 20—50 and 50—100 min intervals, and when 2.0 g/kg were administered the highest values were obtained during the 50—100 min interval. The larger the dose, the slower the iodine concentration fell after passing its peak.

The effect of Biligrafin upon the bile flow was analysed by determining the bile volume per minute in each of the intervals. This study showed the bile volume always to decrease as from the 10—20 min interval. This may in part have been due to deterioration in the animal's general condition as the experiment advanced; the shorter the period elapsing after opening the abdomen, the less marked was the effect of the opera-

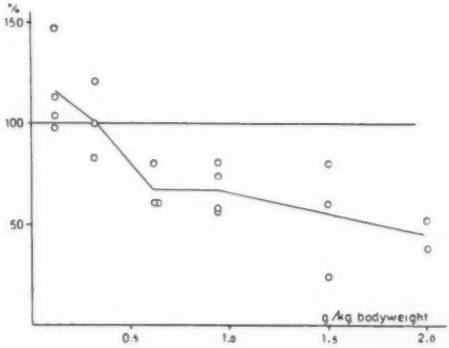


Diagram 4. Relationship between bile flow and the size of the Biligrafin dose. The volume of the control sample is compared with that of the 0—10 min interval and the difference expressed in per cent.

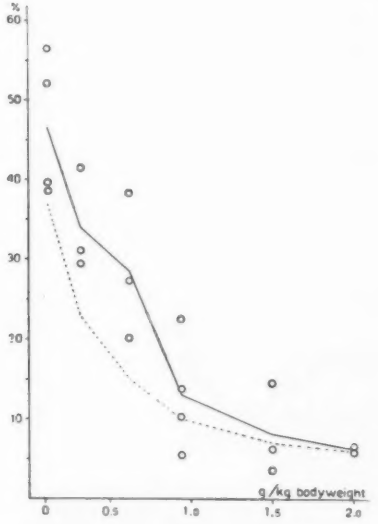


Diagram 5. Percentile excretion in the bile of Biligrafin after different doses based on 110-min values (full line), and contrast medium concentration as a function of the amount of the medium injected, calculated from the 50-min value per 10 ml bile (dots).

tion upon the flow of bile. Consequently, the 0—10 min interval was best compared with the control sample.

A contrast medium dose of 0.12 g/kg bodyweight led to an increase in the bile flow by a mean rate of 16 % in three of four experiments (Diagram 4). A dose of 0.32 g/kg increased the bile flow only in one of three experiments. A further increase in the dose of Biligrafin led to a reduction in the bile flow in all experiments. The fall was steepest up to a dose of 0.62 g/kg; at a maximum dose of 2.0 g/kg bodyweight in two cases this reduction amounted to approximately 50 %.

The intensity of the contrast-bile excretion as determined in the common bile duct was variable. Expressed in milligrams of contrast material excreted per minute, the highest intensity after doses of 0.12 and 0.32 g/kg bodyweight lay between 3 and 5 mg per minute. After the other doses the values were widely dispersed, the highest ranging from 1 to 7 mg per minute.

The total amount of Biligrafin excreted during the whole period of the experiment (110 min) rose after doses of up to 0.62 g/kg bodyweight.

When doses were higher, however, the values fluctuated appreciably. This may be attributable to the joint effects of the total bile volume and the Biligrafin concentration. However, on relating the injected and excreted quantities of contrast medium, it was apparent that after a dose of 0.12 g/kg the mean amount passing through the liver was 47 % of that injected (Diagram 5), whereas the corresponding figure after a dose of 2.0 g/kg was only 6 %. Maximal excretion (57 %) was recorded once after a dose of 0.12 g/kg bodyweight.

The excised gallbladder was examined in 7 instances. It was found to be empty in two cases; in one of these cases the bile flow was scanty, in the other it was normal during the course of the experiment. In the remaining five cases the gallbladder contained bile, the contrast medium concentration of which was analysed. When the doses given were 0.12 and 0.32 g/kg bodyweight, the concentration of contrast medium in the gallbladder was considerably lower than the mean concentration of that in the bile duct. When the dose was 0.94 g/kg, however, the iodine concentration in the gallbladder was appreciably higher than the mean concentration of iodine in the common bile duct.

The renal excretion of Biligrafin was studied in 11 animals throughout the experiment (110 min). Equal doses gave differing total Biligrafin amounts in the urine, despite the fact that the liver and kidneys were found on gross examination to be intact. It was noted also that with doses of between 0.12 and 0.62 g/kg the 'percentage excretion' was uniform and ranged from 22 % to 34 %.

The mean iodine concentration in the urine was always higher than that in the bile of the duct. The highest mean iodine concentration recorded in the urine was 5 %.

Discussion and Conclusions

The present investigation has shown that the percentage excretion of Biligrafin by the liver is greatly dependent upon the size of the dose. The percentage excretion was high when the dose was small, and fell steeply with increasing dosage. Thus, the 2-hour value after a dose of 0.12 g/kg bodyweight was 47 %, but fell to 6 % when 2.0 g/kg were administered. The amount of contrast medium present in the gallbladder at the conclusion of the experiment was so small in the five cases examined (at the most 1.3 %) that it did not in practice alter the percentage excretion value. The concentration in the bile of the duct of this contrast material, and the period elapsing before peak concentration was reached, were also closely related to the amount administered. This relationship is illustrated in Diagram 2.

The amounts of Biligrafin inducing choleresis are reported in the literature to be low, at the most 0.20 g/kg. The present author, as mentioned earlier, also found a dose of 0.12 g/kg to exert a choleretic effect, while 0.32 g/kg led to increased bile flow in only one of three experiments. However, a further increase in the dose gave rise to an appreciable reduction in the flow of bile. A dose of 2.0 g/kg bodyweight reduced the flow by approximately 50 %.

The percentage excretion of the kidneys appears to be considerably less dependent upon the size of the dose than that of the liver. This may account for LEUPOLD & HEUCK's statement (1957) that there is no definite relationship between the patient's weight and renal excretion.

There appear to be no data in the literature permitting an accurate comparison of the capacity to concentrate Biligrafin of the liver, in the rabbit and, respectively, in human subjects. The present writer's approximate calculations suggest the concentration capacity to be as high or higher in the rabbit than in man. The figures were arrived at by relating two statements in the literature with the present results: BILLION's (1954) report (taken from a diagram) that maximal Biligrafin concentration in the bile is approximately 26 % of the amount injected, estimated per 10 ml, compared with the data in Diagrams 5 and 2; and WITZGALL & TREBBIN's (1955) statement that the peak Biligrafin concentration in the bile is over 0.20 %, compared with the data in Diagram 1a.

As mentioned earlier, the highest iodine concentration recorded in the present investigation in the rabbit was 1.5 per cent. This single value was produced by the injection of 0.94 g/kg bodyweight. If this dose were to be given in human subjects, the Biligrafin volume of 40 ml usually used would have to be increased two- to fourfold, according to the patient's weight. Owing to the danger of marked side effects in human subjects of such high doses, this large amount of contrast medium is not to be recommended. The calculations in the foregoing suggest that the Biligrafin quantities used clinically cannot produce a concentration in the bile much over the 1 % level. Employing an experimental substance, JONES, GROHOWSKI, ROBERTSON, RAMSEY, SCHILLING & STRAIN (1948) demonstrated in the dog that a 1 % to 2 % iodine concentration is needed for the roentgenographic demonstration of the biliary tract. As will be seen in the curves attached, the clinical dosage of Biligrafin gives iodine values at the lower limits of the requirements for cholegraphy.

If a standard dose of 40 ml Biligrafin 50 % is used, a subject weighing 50 kg will be given 0.40 g/kg while one weighing 90 kg will receive 0.22 g/kg. The difference between these two doses is 45 %. In the rabbit,

these doses are within the limits at which the bile concentration is most greatly dependent upon the size of the dose of the contrast medium. On the other hand, PAHL (1955) observed that the contrast density in the biliary tract was not always increased by doubling the dose of Biligrafin.

PAHL's observation may be accounted for by discrepancies between individual concentration values. As was found in the present experiments, a dose of 0.12 g/kg bodyweight produced a slightly higher iodine concentration in some experiments than in others of the same series, and approached the 1 % level. In another series, in which the animals were given 0.32 g/kg (over double the dose), the iodine concentration was lower in one of the rabbits than in the others. In these two examples, the iodine concentrations differed only slightly and the eye was not capable of detecting any difference between the roentgen films. Another factor of importance is the length of time after injection at which comparisons are made. As mentioned earlier, the concentration curves decline at a different rate on passing their peak after different doses.

It is clear from what has emerged that a comparison of the contrast density in the biliary tract can scarcely be made when the size of the dose and the timing of the examination differ.

Acknowledgement

The author wishes to express his sincere thanks to A. B. Pharmacia, Uppsala, whose financial aid and iodine analyses made the study possible.

SUMMARY

The excretion by the liver and kidneys and the concentration in the bile and urine of Biligrafin was studied in fistula experiments in healthy rabbits. The importance of the size of the dose and the timing of the examinations is discussed. It was not possible to produce a concentration of iodine exceeding 1.5 % in the bile of the animals; calculations made show that a concentration over the 1 % level is not produced by the quantities of Biligrafin used clinically.

ZUSAMMENFASSUNG

Die Biligrafinausscheidung durch Leber und Nieren und die Konzentration von Biligrafin in der Galle und im Urin wurde an Hand von »Fistel-Experimenten« an gesunden Kaninchen studiert. Die Bedeutung der Dosierung und des Zeitpunktes der Untersuchungen werden diskutiert. Es war nicht möglich eine höhere Jodkonzentration als 1.5 % in der Galle der Tiere zu erzielen; die Berechnungen zeigen, dass die klinisch angewandten Mengen Biligrafin die Konzentration von 1 % nicht übersteigen.

RÉSUMÉ

L'auteur a étudié l'excrétion par le foie et les reins et la concentration dans la bile et les urines de la Biligrafin grâce à des fistules expérimentales chez des lapins sains. Il examine l'influence de la dose administrée et de la chronologie de ces examens. Il n'a pas été possible d'obtenir une concentration d'iode supérieure à 1.5 % dans la bile de ces animaux; les calculs effectués montrent que les quantités de Biligrafin utilisées en clinique ne donnent pas une concentration supérieure à 1 %.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: PROF. GREGERS THOMSEN) AND THE DEPARTMENT OF PAEDIATRIC SURGERY (DIRECTOR: C. C. WINKEL SMITH), RIGSHOSPITALET, COPENHAGEN, DENMARK

CYSTOGRAPHY WITH CONTROLLED FILLING PRESSURE IN CHILDREN

by

Erik Rostgaard Christensen

Modern approaches to the treatment of surgical urinary disorders in children are necessarily associated with an adequate roentgenologic technique. An extensive literature on this subject has accumulated in Scandinavia as well as in other parts of the world; particular attention has been directed to the examination of the lower urinary tract and numerous cystographic techniques for use in children have been published. One of these methods is micturition cystourethrography in which serial exposures are taken during voiding of the bladder in the sitting or erect position (GUDBJERG, KULD HANSEN & HASNER 1958, KJELLBERG, ERICSSON & RUDHE 1957). A serious drawback of this examination is that it is seldom possible in children under the age of 3 or 4 years; moreover, it requires complicated special equipment, and the high gonad dose has to be considered. Other techniques include: 1) the one advocated by BUNGE (1953) and STEWART (1953, 1955) for demonstrating delayed reflux by obtaining films every 15 minutes for a period of 2 or 3 hours; 2) single films during micturition to demonstrate micturition reflux; 3) the introduction into the bladder of 'floating lipiodol' for ascertaining residual urine; 4) manual massage of the filled bladder to increase the

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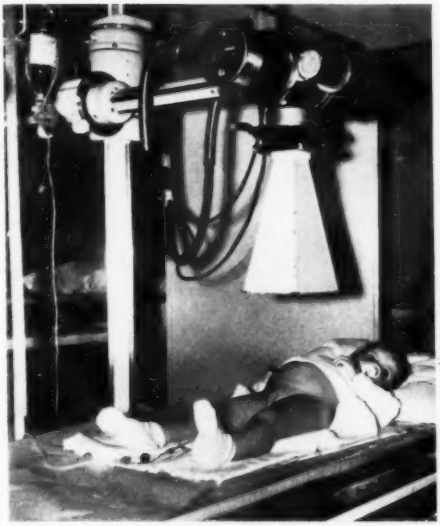


Fig. 1. Arrangement for cystography with controlled filling pressure. The contrast medium is contained in a flask, 60 cm above the symphysis.

tone of the detrusor muscle fibres. Boyce, Harris & Vest (1953) have suggested the so-called 'squat shot' for demonstrating the area of the trigone and the lower parts of the ureters. The patient sits on the couch, dangling the legs over the side, and bending forwards and grasping both ankles with the hands, so that the central ray passes from above through the true pelvis at the posterior margin of the trigone.

Dean, Lattimer & McCoy (1957) have described a method of cystography in which controlled filling pressure is employed through an infusion apparatus. This enables cystograms obtained before and after operation to be compared. This procedure possesses considerable advantages; all forms of reflux may be demonstrated and the evaluation of the result of various reflux operations is rendered possible. It was adopted as a routine method in our department and has been used with certain modification since the middle of 1958. The technique and results are briefly reported below.

Technique

A small Foley catheter (8 to 14) is inserted into the bladder, preferably while the patient is in the ward and still in familiar surroundings. The contrast medium employed is Hypaque (diatrizoate sodium) 12 %, 3 ampoules of 20 ml (45 %) being emptied into an infusion flask containing 240 ml of sterile normal saline. A sterile plastic disposable tube for intravenous infusion is inserted between the catheter and the flask which is fixed on a stand so that the distance from the symphysis to the fluid level in the drip filter is exactly 60 cm (Fig. 1). The drip is started at a rate of about 250 drops per minute corresponding to about 50 ml fluid. At the end of about 5 minutes, the rate decreases quite perceptibly and the drip then ceases. A total of about 200 to 300 ml of contrast medium will flow in, since the bladder of a normal child of 2 years will hold about 200 ml of fluid.

The following films are obtained:

1. A.p. In the event of unilateral reflux or no reflux at all, 30 minutes must pass before a delayed reflux can be demonstrated.

2. Right and left obliques.

3. Micturition films in the oblique plane. If the patient is old enough, these are obtained standing.

3a. If the child cannot void, the bladder is emptied through the catheter in order to find out whether residual urine remains in a pelvis or ureter ('trapping').

4. A.p. following micturition. If contrast medium still remains in a pelvis, ureter or in the bladder, older children are instructed to void three times in all, a film being obtained after each act ('triple voiding'). In the case of infants a film is exposed immediately after the next spontaneous micturition.

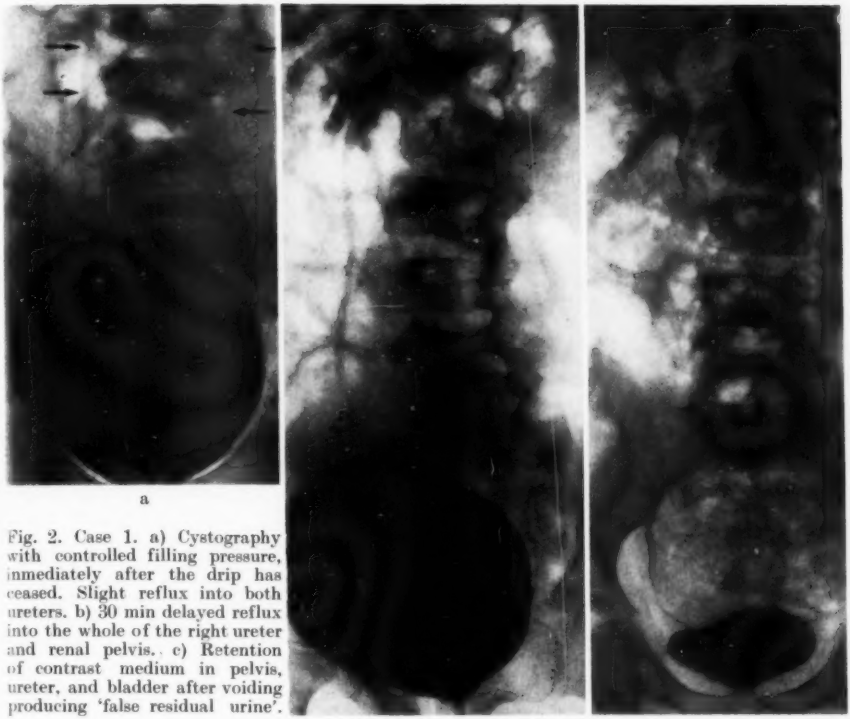
5. In certain instances, special projections, such as the 'squat shot', may be required.

Gonad doses. Dosage measurements carried out by HAMMER-JACOBSEN by the method described previously revealed the following gonad doses: boys (two patients), three films, 75 to 96 kV, total 36 mAs, dose to scrotum 126 mr (2 years), and 30 mr (10 years); girls (four patients), four films, 80 to 92 kV, total 48 mAs, dose to rectum 70 mr (2 years), 63 mr (4 years), 87 mr (6 years), and 64 mr (11 years). Shielding of the scrotum with lead rubber is recommended and the investigation should not be performed in girls except in cases with a reasonable overriding indication.

Results and Discussion

Eighteen cystographic investigations have been performed by this method over a period of 5 months in 16 children between the ages from 1 to 12 years. These consisted of 15 cases of recurrent pyuria and 1 case of incontinence. Ten were found to have reflux (2 boys and 8 girls), in 4 cases, of which one was a boy, combined with sclerosis of the sphincter. The latter condition was present in 6 cases, 4 of which had marked trabeculation of the bladder, associated in a further case with multiple diverticula. The findings were completely normal in the remaining 4 cases.

Females predominate among the abnormal cases. Reflux is not infrequently present in recurrent urinary tract diseases, particularly pyuria. Over a period of a year it was diagnosed in a total of 20 children, 3 boys and 17 girls between the ages from 2 months to 12 years. Six cases had primary reflux, a further 6 cases had bladder neck sclerosis, 5 a double ureter, 1 diverticula, 1 a neurogenic bladder, and 1 simpl



a b c

Fig. 2. Case 1. a) Cystography with controlled filling pressure, immediately after the drip has ceased. Slight reflux into both ureters. b) 30 min delayed reflux into the whole of the right ureter and renal pelvis. c) Retention of contrast medium in pelvis, ureter, and bladder after voiding producing 'false residual urine'.

pyuria. The true condition can be revealed only by micturition cystograms — either by demonstrating a rigid, internal sphincter or a voiding reflux into the frequently ectopic double ureter. During the period the children were investigated partly by micturition cystourethrography during angiocardiography and partly by simple cystography with the injection of contrast medium by means of a syringe. After cystography with controlled filling pressure was introduced, we obtained much greater accuracy in assessing the various forms of reflux and, at the same time, found that the controlled filling pressure permitted comparison of preoperative and postoperative cystograms.

It is of the utmost therapeutic importance to ascertain whether the reflux is due to infravesical obstruction or to primary insufficiency of the ureteral orifice. In infants particularly, great patience has to be expended in obtaining a voiding film of diagnostic value. The following brief case report exemplifies primary reflux.

a b c

Fig. 3. Case 2. a) Cystography with controlled filling pressure; micturition film. Marked reflux into dilated right renal pelvis and ureter, the latter constricted in its distal 10 mm and terminating at the margin of the internal sphincter. b) After the first voiding contrast medium still remains in the right renal pelvis, ureter, and the bladder. c) After the third voiding the appearances are almost unchanged, indicating 'trapping'.

Case 1. Girl, aged 4 1/2 years, whose mother had suffered from nocturnal enuresis until her twelfth year; delivery and postnatal development had been normal. The child was toilet trained, as far as defaecation was concerned, by the age of 2 years. No episodes of urinary tract infection had occurred but there was incontinence of urine, in fact, the child 'oozed' day and night. The urine was sterile, and cystoscopy showed a normal left ureteral orifice, whereas the right orifice was somewhat dilated but functioned normally. Cystography with controlled pressure showed immediately after the inflow a slight reflux into both ureters (Fig. 2 a) and, at the end of half an hour, was greatly increased on the right side, the whole of the ureter and the renal pelvis becoming filled. During micturition there was further reflux with ballooning of the renal pelvis on this side. There were no signs of infravesical obstruction. Contrast medium was present in the bladder after micturition; this consisted of 'false residual urine' and had come down from the right renal pelvis (Fig. 2c). After the second voiding the right renal pelvis and ureter had been completely emptied.

This is thus a case of primary insufficiency of the right ureteral orifice with delayed free reflux, the reflux increasing during micturition. A reflux operation on the ureteral orifice is therefore being planned.

It is important to decide whether functional stenosis of the ureteral orifice, so-called 'trapping', exists or whether the contrast medium can flow freely from the ureter. In the latter case a reflux operation is not always necessary, but expectant treatment may be instituted by the 'triple voiding' method, i. e. the child micturates in three stages (LATIMER et coll. 1956, LUND & HALBORG SØRENSEN 1958). The reflux sometimes does not appear until after some delay because of variation in the pressure in the ureter as a result of antiperistaltic waves. The easiest way of demonstrating this delayed reflux is by obtaining a film 30 minutes after the inflow of the contrast medium. The various forms of reflux found in 10 cystographies with controlled filling pressure were as follows: 7 bilateral, 3 unilateral, 7 free reflux, 3 'trapping', 3 delayed reflux, 2 voiding reflux, and 2 emptying by triple voiding. It must be mentioned that several forms of reflux may be present in the same subject.

The concept of 'trapping' is illustrated by the following case report.

Case 2. Boy, aged 3 1/2 years. Normal delivery. Since he was twelve months old the patient had suffered from recurrent pyuria, accompanied during the previous year by gross haematuria. Urography performed elsewhere prior to admission showed rather poor excretion on the right, and normal findings on the left side. Cystoscopy revealed a large gaping ureteral orifice on the right side, situated at the margin of the internal sphincter; the left orifice was normal. On cystography with controlled filling pressure, the contrast medium was equally distributed between the bladder and a much dilated right ureter and renal pelvis, with no change in the appearances at 30 minutes. The right ureter, the lower 10 mm of which were extremely narrow, terminated at the margin of the internal sphincter. The base of the bladder was seen to assume a normal shape during micturition (Fig. 3a). Following the act there were still perceptible quantities of contrast medium in the bladder as well as in the right renal pelvis and ureter (Fig. 3b), the appearances being practically unchanged after two further acts of micturition and indicating so-called 'trapping' (Fig. 3c). This was a case of an ectopic orifice of the right ureter with insufficiency and stenosis of the orifice and gross dilatation of the proximal part of the ureter. The operation consisted in right nephrectomy, since the kidney proved too damaged to be preserved.

There is some disagreement as to whether reflux may occur in healthy children (BUNGE 1953, GIBSON 1949, JANNACONE & PANZIRONI 1955, KJELLBERG et coll. 1957). According to LUND & HALBORG SØRENSEN reflux in apparently normal subjects is due to an anomaly in which the ureter has a somewhat wide orifice and a short intramural course through the bladder.

It is important not to use contrast media which are local irritants as these in themselves may cause reflux (KJELLBERG et coll.). Diatrizoate sodium is water soluble and in the concentration used does not affect the bladder mucosa. Dilatation of the bladder must not be performed, as this may produce a flare-up of any existing urinary tract infection. The use of a filling pressure of 60 cm water, just above the detrusor muscle pressure of the bladder, ensures that the drip almost ceases when the bladder has been filled.

SUMMARY

A micturition cystographic technique with controlled filling pressure which was employed in a material of sixteen children is described. The method is valuable in the assessment of various reflux operations since the pre- and postoperative cystograms may be compared.

ZUSAMMENFASSUNG

Eine miktions-cystografische Methode mit kontrolliertem Füllungsdruck, welche an 16 Kindern erprobt wurde, wird beschrieben. Die Methode ist wertvoll für die Beurteilung verschiedener Refluxoperationen, da die prae- und postoperativen Cystogramme verglichen werden können.

RÉSUMÉ

Les auteurs ont utilisé sur une série de seize enfants une technique de cystographie mictionnelle avec contrôle de la pression de remplissage; ils décrivent cette méthode. Elle est intéressante pour juger les différentes opérations pour reflux, car elle permet de comparer les cystographies pré- et post-opératoires.

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VARIATIONS IN THE STRIATE AND OTHER CEREBRAL VEINS AFFECTING MEASUREMENTS OF THE 'VENOUS ANGLE'

by

B. Albert Ring

The diagnosis of space-occupying intracranial lesions by cerebral angiography is sometimes made by the presence of abnormal vessels but the most consistent diagnostic finding is vascular displacement. With the recognition of the importance of venous displacement, as well as arterial, the curve of the striate vein (striothalamic), as it passes through the foramen of Monro to join the septal vein, likewise assumed importance and was given the name of the 'venous angle' by KRAYENBÜHL and RICHTER. This term may seem objectionable since the normal course of the vein is a curve and not an angle, but as it has been widely accepted it will be used here for brevity and convenience. Many investigators devised methods of measuring the position of the venous angle for the determination of pathologic displacement. Among these are the reports of UMBACH, MASPES, JOHANSON, and LIN, as quoted by MOKROHISKY et coll., and, further, WOLF et coll., LAINE et coll., and NETTL et coll. These investigators differed about the value of such measurements. JOHANSON found them of little value. NETTL and co-workers, on the basis of many measurements, found that they could localize a tumour just as well by inspection of the deep cerebral veins. WOLF and his group considered their method

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valuable but emphasized that the results should be correlated with all the other findings. LAINE and co-workers when applying their system of measurement believed that they could localize a tumour by the help of only one appropriate film in the venous phase.

The original purpose of the present study was to test the applicability of the method for determining the normal position of the striate vein at the foramen of Monro, as described by LAINE and his colleagues in 1956. A modification of this method was subsequently used, and comparative measurements were made, according to the system described by WOLF and his co-workers in 1955. The orientation charts of LIN were used in some cases, and also other measurements that seemed pertinent.

The material consisted of rapid serial carotid angiograms, from the files of Serafimerlasarettet, taken with the Schönander rapid film changer at a distance of 80 cm. Children under 16 were excluded. Since Laine's method requires the junction of the vein of Galen and the straight sinus as a reference point, those normal cases were selected in which this junction could be accurately outlined. This point was not considered essential for the cases of brain tumour as the method was modified and another point used for reference. The only requirement for selection of abnormal cases was a technically satisfactory examination, showing definite evidence of a tumour that could be well localized either by the angiogram alone or by supplemental air studies. One hundred of both normal and abnormal cases were measured. Composite tracings on oleum paper were made of the deep veins and sinuses of the normal cases, including all possible tributaries and arborizations, since by compiling the findings of many films we were able to record many details that would not be apparent on any one film alone. The measurements were made on the actual films and not on tracings.

Laine's method of measurement calls for a straight line from the junction of the straight sinus and vein of Galen to the limbus sphenoidalis, the normal venous angle then falling in a triangular area 14 × 7 mm with the apex anteriorly. A full size template is given in the publication. Wolf's method is more complex. A base line is drawn from the tuberculum sellae to the inferior margin of the groove of the transverse sinus. A perpendicular is drawn to this line 13 mm behind the tuberculum and the normal venous angle is expected to fall along this line, or not more than 2.5 mm posterior to it. Anterior positions are disregarded. The height of the venous angle is measured by a constant ratio scale on the vertical line, so constructed that one gradation on the scale in the region of the venous angle represents a fixed percentage (34.4 %) of the total

distance to a corresponding gradation on the scale in the region of the vault. Measurements with a similar constant ratio scale are made from the tuberculum sellae to the midpoint of the descending portion of the internal cerebral vein and the inner table, and also to the lowest point of the vein of Galen and the inner table. The percentages used in the latter two scales are 43 % and 48.4 %. This study was based on only 24 normal cases and the authors emphasize that the measurements must be correlated with all other findings. Lin's method is a coordinate system similar to the Vastine-Kinney charts for pineal localization. A baseline is taken from the nasion to, and extending past, the tuberculum sellae. The height of the venous angle is taken at right angles to this line, and the distance of the venous angle above the baseline is plotted against the distance from the baseline to the inner table of the vault through the same point. In the a. p. plane, the longest diameter of the skull is plotted against the distance from the inner table of the frontal bone to the venous angle, along the axis of the longest diameter of the skull. The authors' original limits were later extended to cover greater variations in normal cases and the two limits are referred to as the 'narrow' and 'wider' limits.

Since the normal anatomy of the cerebral veins has been repeatedly described, only a brief description of the structures concerned in this study will be given. The septal vein runs posteriorly, usually joining the striate vein at the foramen of Monro, but not infrequently passing above the foramen, joining the internal cerebral more posteriorly. The continuation of these veins form the internal cerebral vein which runs in the roof of the third ventricle just lateral to the midline, and curves up and back in a smooth arc. Behind the third ventricle the curve is reversed and the vein passes downwards and medially to join its contra-lateral fellow, forming the great vein of Galen, which receives the posterior callosal (posterior cerebral) vein from above and the basal veins from below. The posterior callosal vein drains the superior aspect of the corpus callosum and curves down around the splenium, outlining its position. Although this vein is small it is usually easy to see, and it was observable in all but one of our 100 normal cases. The vein of Galen usually follows the same curve upwards to join the straight sinus which is continuous with the inferior sagittal sinus. The anterior tributaries of the internal cerebral vein usually fill and drain late at angiography (GREITZ), and the central veins therefore are still well filled when most of the contrast medium has disappeared from the superficial veins.

We had difficulty in determining the exact point of reference at the junction of the vein of Galen and the straight sinus, as is required for LAINE's method. The exact point is not clearly stated by the authors,

which would have been useful as the veins and the sinus have appreciable width. It was difficult and in many cases impossible to choose the midpoint of the sinus at the junction, as the posterior walls were seldom seen. The straight sinus in the region of the junction is usually triangular in cross-section, with the apex posteriorly. The apical portion is often too narrow to hold sufficient contrast medium for a radiographic image to be obtained in the lateral projection, and we have moreover in one and the same examination found the apparent width of the sinus to vary from film to film. In lateral projection, the anterior wall of the sinus is its widest point and it was also the one most consistently seen, so we choose the midpoint of the vein of Galen at the anterior border of the sinus for reference. Our results with Laine's method were, however, not satisfactory in that only slightly more than half of the normal cases (55 of 100) gave normal measurements. It may have been that the point of reference was not exactly the same as that taken by LAINE and his group, but since this point is not clearly defined, we were unable to improve on it. Another factor of importance was the normal variations, as described below.

In our material, gross variations in the form of the junction were present in 23 of 100 cases. In these, the vein of Galen proceeded more or less directly backwards instead of following its characteristic curve upwards, so that an appreciable space was left between it and the arc of the posterior callosal vein. The junction in those cases was located from 3 to 8 mm behind the splenium and was, as a rule, somewhat more inferior. It is obvious that the LAINE-template can not be expected to give satisfactory results in such cases.

Even when the vein of Galen followed its usual course, the position of the junction varied considerably, as noted by DECKER, presumably related to the depth of the falx. The degree of variation was checked by finding a constant point on the posterior callosal vein. Since this vein forms a rather smooth arc in its course over the splenium a radius from the center of the hypothetical circle forming this arc, if drawn parallel to the longest axis of the skull, marks the most posterior point. The point can be found as well by drawing a perpendicular to the long axis of the skull, a tangent to the arc. We found this point easy to locate and believe it to be a consistent 'landmark'. In a few cases, in which the vein of Galen apparently lay very close to the splenium, the callosal vein passed slightly lateral to it and was a millimeter or so posterior to the anterior border of the vein of Galen. In such cases, we used the most anterior vessel. By the use of this point, and a crude template of oleum paper, we plotted the position of the junctions of the remaining 77 cases that showed the characteristic curve of the vein of Galen, and found them scattered about the curve of the posterior callosal vein through an arc of 60 degrees.

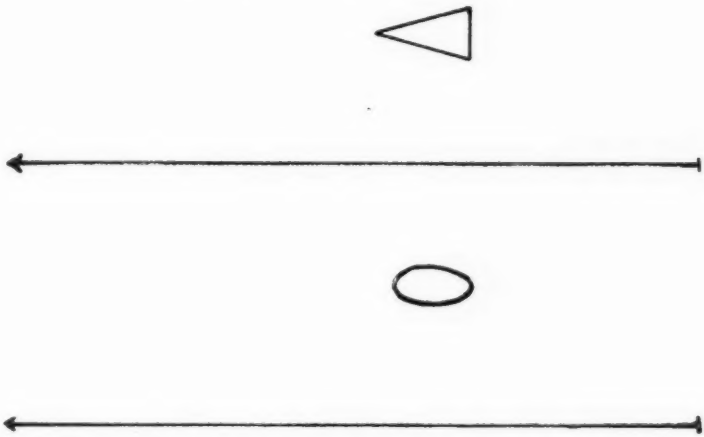


Fig. 1. Upper part: Laine's topogram. Arrow from junction of great vein of Galen and straight sinus to limbus sphenoidalis. Full size. Lower part: Author's modification of Laine's topogram. Arrow from most posterior point of posterior callosal vein to limbus sphenoidalis. Full size.

30 degrees above and below the most posterior point, with the majority falling very slightly inferior to it.

One variation described by JOHANSON in his dissections, in which the vein of Galen follows a characteristic curve but bends back upon itself to enter the sinus, was not seen in any of our cases, which suggests that this finding may have been due to a post-mortem change. The dependency of the posterior skull of the supine cadaver may induce a sag of the supratentorial contents, and since the vein is immobilized by the rigid falx at its entrance to the straight sinus, a posterior and inferior displacement of its more rostral portion could result in such an angulation.

We believe the difference in frequency of gross variations of the junction, in our material as compared with JOHANSON's dissections, can best be explained by the same hypothesis. In cases where the vein of Galen is only a short distance behind the splenium, the post-mortem sag could obliterate the space between the two. Only the more marked variants, with the vein going almost directly backwards and leaving a large space between the vein and the splenium, would be seen at dissection. Out of 23 cases, 8 (8 % of the total) fell in this category which exactly corresponds to JOHANSON's percentage, with 6 of 75.

Variants of the basal vein were not specifically sought, but two cases in which this vein drained directly into the straight sinus below the vein of Galen were noted in the 100 normal cases.

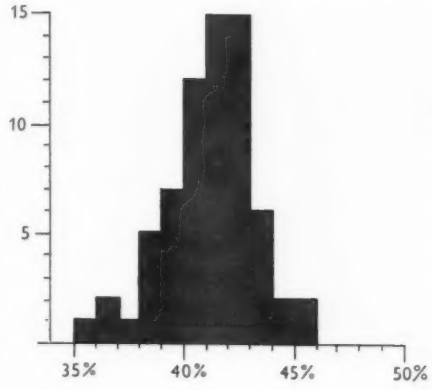
A modification of Laine's method was devised in order to overcome the difficulties of a poorly defined reference point and the variations at the junction of the vein of Galen and the straight sinus. The most posterior point of the posterior callosal vein was chosen as the point of reference, and a line from this was drawn through the limbus sphenoidalis, as in Laine's original template. The normal cases were again measured; in 73 of the 100, the venous angle fell in an oval area of about 6 × 8 mm. Thus, the author's modification, although it cannot be said to ensure the desired accuracy, nevertheless leads to considerably better results than those obtained by Laine's original method. The same cases were measured by Wolf's method, and 62 out of the 100 gave normal measurements. There was little agreement between the two procedures, and only 51 cases were 'normal' according to both.

Because of the use of the most posterior point of the posterior callosal vein we were interested in finding out if it were constant in relation to the skull and tuberculum sellae. Measurements revealed that it was not; the actual distance from the tuberculum sellae ranged from 6.4 to 8.1 cm and the percentage of the total distance from tuberculum sellae to the inner table through this point ranged from 50 to 63 %. The majority fell between 52 and 58 %, with 55 % being the average. These measurements appeared to be considerably influenced by the shape of the skull.

As we considered ourselves to have overcome, by our modification of Laine's method, the effects of variants at the starting point of measurement, we investigated the other point in the system, the venous angle, and its relation to variations in the internal cerebral vein and tributaries.

A sketch of the anatomy of the internal cerebral vein has been given. The tributaries that can be expected to be seen on angiography are the following veins: the septal, which is sometimes doubled or forked, the striate vein, and the choroid vein which often empties into the striate and is usually difficult to identify unless the posterior choroid artery, which arises from the posterior cerebral, is filled. In addition, a vein from the posterior horn, emptying into the distal part of the internal cerebral, is usually seen, although it is small. There may be significant tributaries to the internal cerebral vein anywhere along its length, but many of them join in the region where the downward curve begins as though draining from the trigone, and we assume such veins are the ones referred to by LAINE as 'trigonal' veins. The septal vein may receive tributaries that drain in an anterior manner simulating the curve of the striate vein, and these may be confused with the striate. Nine such tributaries to the septal vein were seen in the 100 normal cases.

There is considerable variation in the number of significant visible tributaries to the septal and internal cerebral veins, and in our materia



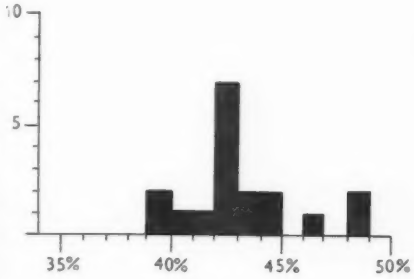
a

Diagrams 1a—c. Distances from venous angle to inner table of frontal bone expressed in percentages of total length of the skull between inner tables. Percentages on abcissa, number of cases on ordinate.

a) Results in 77 cases with 'normal' venous angle.

b) 19 cases with false venous angle.

c) Location of foramen of Monro from encephalography, in the same 19 cases.



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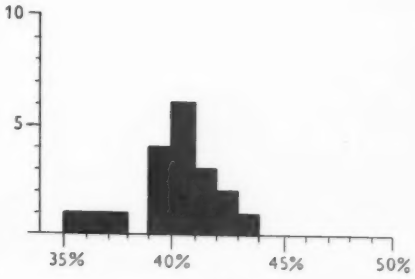

c

they varied from 2 to 5 with the following frequency: 2 tributaries in 30 cases, 3 tributaries in 58, four tributaries in 11, and 5 in one case. The tributaries were large, with extensive arborizations in the cases with only two tributaries visible, while they were small with scanty arborization in the two cases with 5 tributaries.

Mokrohisky, Lin, Stauffer and Herbert were, to our knowledge, first in calling attention to the fact that the striate vein is not always visible and that a tributary, forming what they described as a false venous angle, appears to replace it. Johanson, in his dissections, found the anatomical basis for this in what he described as very small striate veins in the presence of 'deputizing veins', in 15 out of 75 hemispheres. Since we had a large number of normal carotid angiograms that gave abnormal measurements by one or the other of the two methods used, an encephalographic checking of the position of the foramen of

Monro was made in the cases in which this examination had been performed. Thanks to the well-known thoroughness of the neurological and neurosurgical work at Serafimerlasarettet, there were 41 cases with encephalograms out of the 49 cases in question. In a comparison of the two examinations we found that in 19 cases the apparent venous angle did not correspond to the foramen of Monro. Considerable care was taken to ensure that this was a true finding and not due to variations in technique. In all cases it was possible to find some film, showing the foramen, that could be superimposed on the angiographic film. In several cases there was an extension of air from the quadrigeminal cistern (cistern of the great vein of Galen), into the cistern of the roof of the third ventricle, so that the posterior portion of the internal cerebral vein could be accurately located. We gained further confidence in the veracity of our findings with the 22 cases in which the venous angle was at the foramen, since in all of these superimposition could be obtained without difficulty.

Of the 19 cases, 6 also had carotid angiograms of the opposite side, and these showed a striate vein in the usual position in 5, while in one case the anomaly was bilateral.

We were interested in the reliability of measurements to separate the false from the true venous angle. Of the 19 cases, 5 were abnormal by both methods, 12 were abnormal only by the author's modification o Laine's method, and 13 only by Wolf's.

Using Lin's charts on these 19 cases we found 11 to be completely within normal limits, 4 to be outside the wider limits in one plane, 4 outside the narrow limits but within the wider in one plane only, but none that were outside the wider limits in both planes.

Since the apparent displacement of the venous angle was primarily in the a. p. plane of the skull, measurements were taken as described for Lin's orientation charts and the distance from the inner table to the venous angle, expressed as a percentage of the total a. p. length of the skull between the inner tables. After excluding the 19 cases with a false venous angle, and four others in which the inner table was obscured at the point of measurement, the figures for the 77 remaining cases ranged from 36 to 46 %, with 69 of the 77 cases, or 89 %, falling between 38 and 44 % (See Diagram 1a). For comparison, the same figures for the 19 false venous angles are given in Diagram 1b, and it is noteworthy that only 3 are outside the normal range. Measurements were also applied to the foramen of Monro, where the venous angle should have been seen in these same 19 cases, and results are shown in Diagram 1c. The mean grouping of this last series is somewhat more anterior than the group as a whole, but the differences and numbers involved are too small to be statistically significant.

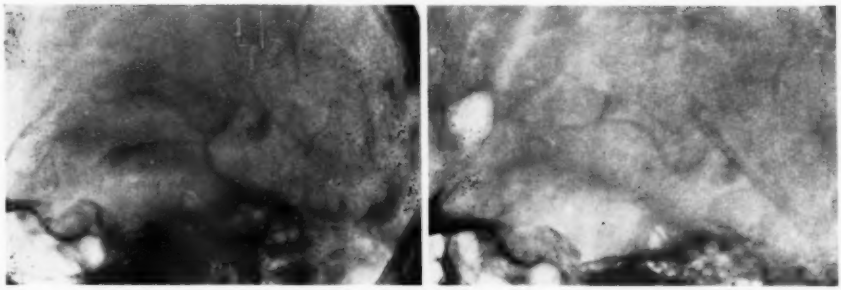

Fig. 2. Normal phlebography of right and left sides of a patient. a) Left side, characteristic curve of the striate vein. b) Right side, showing a typical false venous angle. (Air in anterior horns from previous encephalography.)

Mokrohisky and co-workers gave four criteria for recognition of the false venous angle. In brief, their criteria were: absence of the ascending portion of the internal cerebral vein with the venous angle located too far posteriorly, a 'dot' on the tributary forming the false venous angle which marks the lateral entrance of the caudate vein, loss of the smooth curve of the striate, and the tributary vein entering the internal cerebral at right angles. We would add another finding, associated with the posterior position of the false venous angle, and represented by unusually long tributaries running back from the region of the anterior horn (see Fig. 2).

Our experience in recognizing the false venous angle has not been wholly satisfactory, although the findings indicate that inspection is equal or superior to any other single method of determination. Our score for the 19 cases is as follows: nine would have been considered normal and only 5 were obvious; one case showed three distinguishing features, the false venous angle being far posterior, an abnormal curve of the tributary forming the false venous angle, and a prominent 'dot' (see Fig. 3, top left); four others were similar but lacked the 'dot'. The five detectable, but not obvious, were as follows: in 2 cases the false venous angle was close to the foramen of Monro but the apparent striate vein had an abnormal curve and a prominent 'dot' (see Fig. 3, top right); one case was recognized because of the course of the septal vein under the venous angle (see Fig. 3, lower left); in 2 cases a prominent posterior tributary was detected but a more anterior tributary to the septal vein resembling the striate was recognized because of a difference in the curve of the septal and internal cerebral veins (see Fig. 3, lower right).

It is obvious that recognition of one tributary, simulating the venous angle is not a guarantee that a more anterior vein is the striate. The

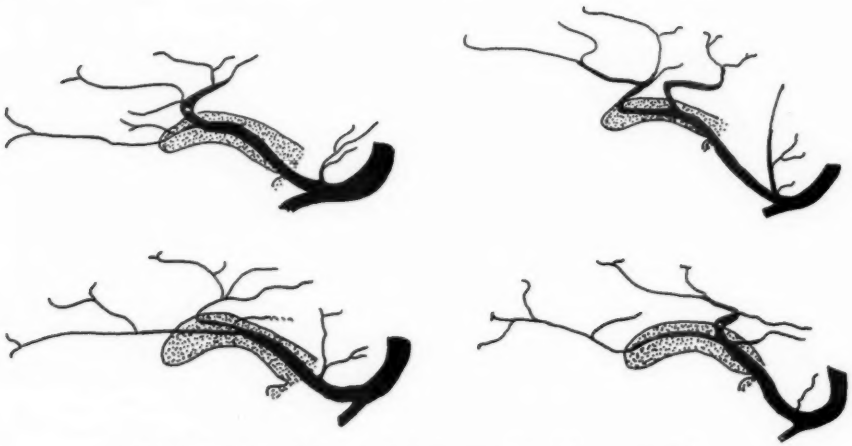

Fig. 3. Drawings of the veins in four cases with a false venous angle.

location of the vein of the choroid plexus was not helpful in our experience, as suggested by MOKROHISKY et coll., as in several cases it opened into the internal cerebral directly behind the false venous angle.

We do not believe the absence of filling of the striate vein to be due to some fault of technique, since fine arborizations of the other deep veins were seen consistently. It seems unlikely that we have overlooked striate veins that may have been filled only temporarily, as we were aware of this possibility and found several cases in which this occurred. The films were checked and re-checked after comparison with the encephalograms, with the advantage of knowing where the striate should be, and since the technique in use at Serafimerlasarettet allows the taking of from 10 to 15 lateral films in the venous phase at each examination, multiple films were available for study. We cannot exclude the possibility of a very early and brief filling of some small striate vein that could have happened to lie directly under a large superficial one, but it seems unlikely that such a coincidence could have occurred very often.

Our final figures of 19 cases of false venous angle out of 100 may be too low. In the eight cases measuring abnormally, but without encephalographic check, there may have been others that we are unable to prove. We have no reason to be sure that the two systems of measurement enabled us to detect every false venous angle, wherefore the 19 % should be regarded as a conservative minimum.

After completing the investigation of normal cases, we measured the position of the venous angle in 100 patients having brain tumours, using

Table

Results of measurements of the position of the venous angle in 100 cases of brain tumours by the author's modification of Laine's method and by Wolf's method, respectively. Four cases were excluded because of an obviously false venous angle.

Location of tumour	Number		Satisfactory	Not helpful	Misleading
Occipital	2	Ring	1	1	—
		Wolf	1	1	—
Parietal and Rolandic	23	Ring	16	7	—
		Wolf	13	9	1
Posterior and medial frontal	6	Ring	6	—	—
		Wolf	6	—	—
Anterior frontal Fronto-polar	18	Ring	18	—	—
		Wolf	18	—	—
Sella and supra-sellar	6	Ring	6	—	—
		Wolf	6	—	—
Temporal	26	Ring	16	9	1
		Wolf	14	9	3
Central	15	Ring	11	3	1
		Wolf	10	4	1
Total	96	Ring	74	20	2
		Wolf	68	23	5

our modification of Laine's technique, and also Wolf's template. We must emphasize that Wolf's method in these cases was used only for the position of the venous angle, and such a restricted use is not a fair test of its potential usefulness. Since we were primarily interested in the results obtained by our modification of Laine's method, the location of the tumour was recorded in accordance with the anatomical divisions that he and his colleagues described in connection with the use of their original measurement method. The results were recorded as satisfactory (displacement occurring in a manner expected from the location of the tumour), not helpful, and misleading. The results are summarized in the Table above.

Four of the 100 cases are not included in the total as they showed a definite false venous angle, located far posteriorly. Two occurred in frontal tumours and would have given satisfactory measurements, but in the other two, one temporal and one parietal, the measurements would have been misleading.

Of the 96 remaining abnormal cases, measurements were satisfactory in 74 by our method and 68 for Wolf's. (The results for the normal cases were 73 and 62, respectively.) The measurements were not helpful in 20 cases by our method and 23 by Wolf's. Misleading results were obtained in 2 cases by our method and in 5 by Wolf's.

All tumours in the frontal area, including those in the sella and supra-

sellar region gave satisfactory measurements. Parietal and temporal tumours had the highest failure rate, with central tumours being intermediate. We can draw no conclusions regarding occipital tumours as there were only two. These findings are basically in agreement with those of NETTL and his co-workers when using similar measurements. Unsatisfactory results in temporal and parietal tumours are probably to be expected since they produce primarily a lateral and oblique displacement which must be considerable in order to appear in lateral films.

The appearance of the striate and internal cerebral vein was recorded as either normal or questionably abnormal, definitely abnormal, or markedly abnormal. We found 41 cases to appear markedly abnormal and of these, 40 measured satisfactorily, and 1 was not helpful with our modification of Laine's method. Similar figures for Wolf's template were 38 and 3, while neither gave misleading results. At the other extreme, 19 cases were considered as appearing normal or only questionably abnormal. Of these, our method led to satisfactory measurements in 8, not helpful in 9 and misleading in 2. Using Wolf's template, the figures were 6, 8 and 5, respectively. It is noteworthy that all the misleading measurements in the entire series (excluding the 4 cases with a definite false venous angle) were in this small group. Hence we would question the wisdom of depending on measurements when other findings are equivocal.

There is good correlation between obvious changes in the striate and internal cerebral veins and the position of the tumour, as could be expected. The majority of the last 19 cases represented temporal and parietal tumours, although there were a few in this location that produced marked changes in the veins. To use a positive instead of a negative approach, we might say that tumours in the temporal and parietal regions give satisfactory measurements if they are big enough to cause obvious changes in the striate and internal cerebral veins, as seen in the lateral view.

We feel certain that a large number of false venous angles were measured in this series although only four were excluded for this reason. With distortion of the deep veins from pressure of a tumour the differences that enabled us to identify false venous angles in normal subjects could not be appreciated in any but the obvious. We made no attempt to find encephalograms to outline the foramen of Monro except in a few cases where air studies had been requested for more precise localization, since both examinations would have to have been performed almost at the same time to allow any valid conclusions.

Conclusions

1. The junction of the vein of Galen and the straight sinus is not constant in relation to the splenium of the corpus callosum, which is in agreement with JOHANSON's work, even in cases where a characteristic curve of the vein of Galen is present.

2. The most posterior point of the splenium of the corpus callosum is easily and precisely located for a point of reference, although it is not constant in relation to the tuberculum sellae and the posterior skull.

3. The methods of measurement employed in this work give a large number of false positive findings in normal cases (27 % by our modification of Laine's method, 38 % with Wolf's, and 45 % by Laine's original method).

4. The striate vein and the true venous angle are never seen in a significant number of cases (a minimum of 19 % in this series). About one fourth of these are obvious, another fourth can be recognized in normal cases by close inspection, and in about half appeared impossible to detect without locating the foramen of Monro by air studies.

The frequency with which a false venous angle simulated the true one came as a surprise to us but we do not think this is as significant as it might appear. In most of the cases, the false venous angle was only a short distance from the foramen of Monro, and the few cases in which this distance is significant are obvious if the possibility is kept in mind. The majority of false venous angles fall well within the limits of normal variations. Over half of the number of false positive findings in the normal cases were due not to false venous angles but merely represented cases of normal venous angle outside the mean accepted for the measurements.

5. In cases with brain tumours, unsatisfactory results are found about as often as in normal cases. Tumours in the frontal area can in most cases be satisfactorily localized by measurements. Temporal and parietal tumours, unless big enough to cause obvious changes in the striate and internal cerebral veins in the lateral projection, cannot be consistently localized, and the measurements may give misleading information.

We believe that there is a double source of error in these or any system of measurement with which we are acquainted. The first is inherent in the procedure since an attempt is made to measure a threedimensional displacement in a single plane. The second is inherent in the normal anatomy. The range of normal variations is so great that we must choose between a mean for the majority, which may give false positive findings

in normal cases and misleading findings in abnormal ones, or extend the limits to cover all normal cases, and then only the most gross and extensive displacements can be detected.

We were more impressed by the value of venous displacements as seen in the half-axial view and agree with NETTL and his colleagues that much more information can be obtained concerning venous displacement when serial films in this projection are available.

In conclusion, we feel that the chief value of any system of measurement applied to the deep cerebral veins lies not in the actual results of the measurements, but in the combination of knowledge of the normal anatomy and the careful inspection that is necessary for the use of such measurements.

Acknowledgement

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SUMMARY

The author measured the position of the venous angle on cerebral phlebograms by the two methods of Laine and Wolf, and found high percentages of false positives in the normal material, and not helpful or misleading results in the abnormal. After a study of the anatomical variations of the measurement point used by Laine's method, a modification of this method has been introduced by the author. This modified method gives much greater accuracy but cannot be considered fully satisfactory.

ZUSAMMENFASSUNG

Der Autor mass nach den zwei Methoden von Laine und Wolf die Lage des Venenwinkels am cerebralen Phlebogramm und fand hohe Prozentsätze von falschen positiven Befunden an Normalfällen und nicht behilfliche, oder irreführende Befunde an abnormen Fällen. Nach der Klarstellung der anatomischen Varianten des Messpunktes hat der Verfasser die Methode von Laine modifiziert. Diese abgeänderte Methode ist bedeutend sicherer, wenn auch nicht ganz zufriedenstellend.

RÉSUMÉ

L'auteur a repéré la position de l'angle veineux sur des phlébographies cérébrales par les deux méthodes de Laine et de Wolf et a trouvé une forte proportion de cas faussement positifs dans une série normale et des résultats sans intérêt ou trompeurs dans des cas pathologiques. Après avoir étudié les variations anatomiques du point utilisé dans la méthode de Laine, l'auteur a modifié cette méthode. La méthode modifiée donne des résultats notablement plus sûrs, mais n'est cependant pas complètement satisfaisante.

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FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR: EUGENE F. VAN EPPS), STATE UNIVERSITY OF IOWA, SCHOOL OF MEDICINE, IOWA CITY, IOWA, U. S. A.

A CRITIQUE OF EXPERIMENTAL LYMPHOGRAPHY

by

Harry W. Fischer

Although much has been written of indirect lymphography in animal experimentation, the expectations for clinical usefulness of this technic were not previously seriously entertained because of inherent disadvantages. Indirect lymphography is defined as the radiographic demonstration of lymph structures by injection of contrast material into the tissues or body cavities, the contrast substance then moving from its injection site into lymph channels. Direct lymphography is the introduction of contrast material into lymph trunk or node. MALEC and KOLC (1958) improved the indirect method by the addition of vasopressor substances to the interstitially injected contrast media, in laboratory animals. They reported that early clinical trials have indicated the value of the new method.

After learning of MALEC and KOLC's results, I was able to confirm that improved lymphograms result from the addition of adrenalin or neosynephrin to water soluble iodide contrast agents injected into the tissues. Experiments were conducted utilizing the two hind legs of the same dog, comparing lymphograms resulting from the injection of contrast solutions with and without vasopressor drugs. In this manner, using iden-

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Fig. 1. Comparison of indirect lymphogram (on the left) with a direct lymphogram (on the right) of the same dog's lower leg. It may be seen that much higher quality in completeness and clarity of detail is obtained by direct lymphography. Identical exposure factors.

Fig. 2. On the left is a radiogram of a dog's hind paw after the injection of 4 ml of Thorotrast (dosage producing a good indirect lymphogram). On the right, the same paw is seen 10 days later with the radiopaque material more diffusely distributed in the tissue, but with the major portion remaining at the place of injection.

tical injection and radiographic technics, technical differences could be minimized. A typical experiment consisted in the injection of contrast solution alone into the foot pad of the left leg, and the injection of contrast solution plus vasopressor substance into the right. Dogs weighing 8 to 16 kg were injected under nembutal anesthesia. The limbs were not constricted, nor was there any manipulation or massage performed. Films were made at 15 or 30 minute intervals for two hours. The contrast media compared were 50 % Diodrast (iodopyracet, Winthrop), 50 % Urokon (sodium acetrizoate, Mallinckrodt), and 50 % Hypaque (diatrizoate sodium, Winthrop). The volume of contrast solution injected varied from 4 to 12 ml with the usual injection being 5 to 7 ml. Adrenalin chloride (1 : 1 000) solution was employed in a dose of 0.002 or 0.02 ml per ml of contrast solution. Neosynephrin hydrochloride (10 mg/ml) was employed in a dose of 0.01 ml per ml.

In each instance, the addition of the vasopressor agent to the contrast material gave a better lymphogram than the contrast material alone. The lesser content of adrenalin appeared to produce as good lymphograms

as the larger amount. The lesser amount was about equal to the concentration of adrenalin advised for inclusion in the procaine for local infiltrative anesthesia; the large dose was ten times the lesser amount. Hyaluronidase, added to the contrast agent and vasopressor substance did not improve the lymphogram.

In animals, indirect lymphograms of best quality are obtained by the injection of Thorotrast (colloidalthorium dioxide) into the tissue. The main objection to the use of Thorotrast are two: (1) A major portion (75 to 95 %) of Thorotrast remains locally at the injection site (cf. Fig. 2), and (2) Thorotrast, because of its radioactivity, is not considered safe for long retention in any tissue. The magnitude of this danger, however, is much disputed. The lymphogram by indirect technic is largely produced by the rupture of fine interstitial lymph channels by the injection needle, so that contrast material initially flows directly into the lymph structures (BELLMAN & ODÉN 1957). Some contrast material may in the early phase enter through the intact lymphatic wall or through the pores of the wall. When colloidal materials are injected, some particles are transported into the trunks and to the nodes by tissues macrophages. The use of vasopressor drugs for indirect lymphography is based on the assumption that decrease in absorption by blood capillaries allows increased absorption by the lymphatics.

Volume for volume, Hypaque gave better lymphograms, but a lengthy comparison of the contrast agents with each other was not made. Histological study of the injected tissue was not made. Increase in the volume of the contrast agent aided the production of a satisfactory lymphogram, but the volume of fluid that could be quickly injected was limited by the size of the paw.

Despite the undisputed improvement in quality of the lymphogram resulting from use of vasopressor substances, the examination was, essentially, unsatisfactory in comparison with the demonstration of detail that is consistently possible by direct lymphography. If the excellent quality of a direct lymphogram of the hind leg of the dog is assumed to be ++++ the indirect lymphogram with soluble contrast agent and vasopressor would have to be considered + to ++ at the very best, with many being inferior to this evaluation (see Fig. 1). The demonstration of inguinal and pelvic lymph structures is even poorer.

Not only are the lymphograms obtained by indirect injection with the aid of vasopressor agents much inferior in radiographic contrast to direct lymphograms, but two inherent dangers exist: (1) Certain water soluble organic iodide compounds upon interstitial injection cause tissue damage, and (2) interstitially injected materials do not flow uniformly and constantly through the regional lymph nodes and trunks. When iodopyracet and sodium acetrizoate were injected for indirect lymph-

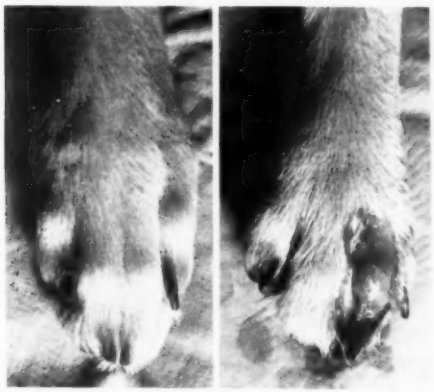

Fig. 3. Dog's hind paw before injection of 8 ml 50 % Urokon with 0.16 ml of 1 : 1 000 adrenalin into the foot pad for production of indirect lymphogram (left). On the right, same paw four days after injection showing edema and ulceration.

graphy into the foot pads of an average sized dog, much edema resulted. In some cases necrosis of soft tissue resulted after several days (Fig. 3). Diatrizoate sodium was much less productive of damage to tissue locally, producing little swelling and no necrosis. Observations on other organ systems tend to correlate with this information. Sodium acetrizoate has been noted to have a much stronger chemotoxic effect on the blood-brain barrier than diatrizoate sodium or iodopyracet (WHITELEATHER & DESAUSURE 1956). LINDGREN and TÖRNELL (1958) found a much stronger chemo-toxic effect on smooth muscle cells with sodium acetrizoate than with diatrizoate sodium. BELLMAN and ODÉN (1957) noted tissue necrosis in rabbit ears with Umbradil 35 % (iodopyracet), but not with Thorotrast in their microlymphangiography experiments. Although local tissue damage occurred whether vasopressor agent was added to the contrast material or not, vasopressor agents would be expected by virtue of their slowing of the absorption to increase the local toxicity of the contrast agent. Vasopressor agents when used with local anesthetics have been suspected to cause tissue necrosis in some instances. Similarly, the use of larger volumes or the use of more concentrated solutions of contrast agents which might be utilized to produce better lymphograms would be expected to be more harmful locally.

MALEC and KOLC are evidently aware of tissue damage, but do not stress this disadvantage. They advise the use of their method only when the site of injection of contrast material is to be surgically excised. This limitation would almost preclude any worthwhile clinical application.

Direct lymphography employs a small incision and minimal dissection at the site of injection. Damage from the contrast agent locally does not occur. Damage from the contrast agent to the lymphatic structures distant from the injection site can be minimized by flushing out of the contrast material with saline solution following the obtaining of radiograms, particularly when a catheter has been secured in the lymph trunk. If lymphography is to be clinically useful no harm must be inflicted on tissue, lymphatic or other, and lymphography must precede and supplant present day diagnostic surgical explorative procedures. Indirect lymphography as it now stands could only be used in a few special situations and only in relation to the surgical excision of the injected tissue.

Irregularity of uptake of interstitially injected radioactive gold colloid by nodes uninvolved by neoplasm has been noted. (HULTBORN et coll. 1955.) Irregularity of staining of regional nodes is also apparent when colloidal blue dyes are injected interstitially. Lymph flows through only part of a node while at other times the whole node is permeated by the lymph. A technic which can not be depended upon to consistently fill nodes and trunks completely and constantly, can obviously not be very useful clinically.

Direct lymphography, perhaps by virtue of the higher injection pressure, or by its supplying of greater volumes of contrast material to the node within a short time, or by reason of factors unknown, allows the best filling of most nodes in a regional group. By the direct technic, I have observed repeatedly the filling of nodes and trunks which were not filled by the indirect technic.

MALEC and KOLC report on one patient with breast carcinoma. This one appearance of non-filling of a trunk in one patient can not be considered sufficient demonstration of clinical applicability. From animal experiments (and we think this to be true also in humans) we know that when a trunk is not contrast-filled, or when there is an appearance of blockage, actual block can not be deducted. An appearance as described may be due to failure to inject adequate amounts of contrast material, or enough material may have been originally injected but rapidly diluted by lymph flowing in from tributary trunks.

We do not yet know the clinical applicability of either indirect or direct lymphography for the study of node abnormality. Direct lymphography for the clinical study of lymphedema is well established (KINMONTH 1955). At the present, my colleagues, LAWRENCE and KRONEWETTER and I are performing cannulization and injection of lymph trunks in the lower legs of patients. We are endeavoring to demonstrate inguinal and pelvic lymphatic structures, thereby investigating whether it would be possible to demonstrate involvement of nodes by neoplasm. The difficulties being encountered are formidable and at this stage the prospects are not

unqualifiedly encouraging. From animal experiments we already know that direct lymphography by reason of its completeness of filling of lymphatic structures of the extremity and pelvis, without damage to tissues, offers a better chance of obtaining information than does indirect lymphography.

Admittedly, direct lymphography is in a stage of infancy, maybe even of prematurity, because of the limitation of available contrast materials (TJERNBERG 1956, FISCHER and ZIMMERMAN 1959). When more clinical work has been assessed, statements can be based on ascertained facts rather than by hypotheses derived from animal experiments. It does seem reasonable to be critical of claims for indirect lymphography. The addition of vasopressor substances to the contrast material does not contain enough promise to be more than an interesting laboratory finding. Better contrast materials, it is true, would be helpful, but hope for obtaining complete, detailed lymphograms by the indirect method does not seem justified in our present state of knowledge. Failure with indirect technics should not lead to discouragement and abandonment of trials for human lymphography by the direct method.

SUMMARY

A critical comparison is made between direct and indirect lymphographic technics. The use of direct lymphography for investigation of lymph node abnormality in man is advocated.

ZUSAMMENFASSUNG

Ein kritischer Vergleich zwischen direkter und indirekter lymphographischer Technik wird angestellt. Die Anwendung der direkten Lymphographie für die Untersuchung von Lymphknotenabnormitäten des Menschen wird verfochten.

RÉSUMÉ

L'auteur établit une comparaison critique entre les techniques de lymphographie directe et indirecte. Il préconise, pour la recherche des anomalies ganglionnaires chez l'homme, l'emploi de la lymphographie directe.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: T. RYDMAN) AND THE SURGICAL DEPARTMENT (DIRECTOR: N. TOLAGEN), CENTRALLASARETTET, ÖREBRO, AND THE DEPARTMENT OF PATHOLOGY (DIRECTOR: PROF. Å. WILTON), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

MUCINOUS CYSTIC DISSECTING INTRAMURAL DEGENERATION OF THE POPLITEAL ARTERY

by

T. Andersson, B. Göthman and *K. Lindberg*

HIERTONN, LINDBERG, & ROB in 1957 gave an account of four cases, not previously described in detail, of cystic degeneration of the adventitia of the popliteal artery. A more thorough analysis of one of the cases was subsequently reported by HIERTONN & LINDBERG (1957). A probably similar condition in the iliac artery was described by ATKINS & KEY (1946) although no detailed histologic investigation had been made.

Both the clinical and patho-anatomic features were fairly uniform in the four cases of HIERTONN et coll. The subjects were young males and presented the following common characteristics: 1) Sudden onset of cramp in the calf; no history of trauma. 2) Intermittent claudication. 3) Local stenosis and/or occlusion of the popliteal artery. 4) Absence of general arterial changes. 5) Intramural cyst formation outwards to the media, compressing the arterial lumen. 6) Contents of the cyst gelatinous and under high tension. 7) Walls of the cyst lined with flattened cells. 8) Structures of the cystic wall suggesting mucinous degeneration. The diseased arterial segment was resected in all four cases, and the defect bridged by a vessel graft.

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The present authors have had the opportunity of following a case greatly resembling those previously described. It nevertheless displayed certain histologic differences which may contribute to the elucidation of the pathogenesis of lesions of this type; these lay in the relations of the cystic changes to the adventitia and media of the vessel wall.

Case report

Male, aged 48, factory worker, about a year previously had developed cramp and numbness in the left leg on walking any distance, symptoms which had persisted but not markedly progressed. Preliminary arteriography at another hospital showed occlusion of the left femoral artery about 10 cm above the knee.

Arteriographic investigation (T. Andersson) showed occlusion of the left femoral artery. The wall of the artery was slightly irregular for a length of 5 cm immediately proximal to the occlusion. Otherwise no vascular changes were demonstrated in either leg.

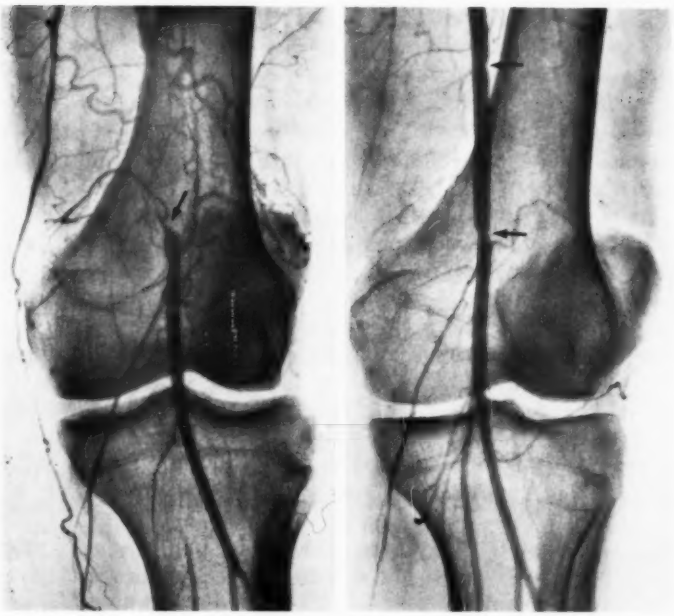
Selective arteriography of the left femoral artery (for examination of the vascular bed distal to the occlusion) demonstrated that segmental occlusion was present in the distal 6 cm of the femoral artery and the adjoining part of the popliteal artery. Below this, the popliteal artery was seen to be gradually tapered until it became uniform and regular and filled via a relatively well developed system of tortuous collateral vessels (Fig. 1a).

Operation (B. Göthman): Exposure of the popliteal artery and lower part of the femoral artery disclosed a fusiform swelling, about 8 cm long, above and below which the vessel appeared normal. On dissection the swelling was found to be a ganglion-like, cystic formation, with a semi-transparent gelatinous content; it was arising, as far as could be judged, from the adventitia. There was total occlusion of the lumen. The collateral system was well developed. The involved segment of the vessel was resected and replaced by an arterial graft.

Histologic examination (K. Lindberg): Examination of the resected part of the artery showed that the lumen was obliterated by a thrombus, part of which showed fairly advanced organisation, particularly superiorly. There was no intimal thickening. Numerous capillaries were visible in the outer layer of the media; the inner layers of the media were partly fibrotic, and had a decreased content of muscle cells.

A cystic formation, emptied of its contents, lay within the outer parts of the vessel wall and occupied about half the circumference, the greater part of the sac being endothelialized. It was bordered internally by the media of the artery, and externally chiefly by the adventitia with the elastica interna. At the upper pole of the sac, the outermost layer of the media was seen to be split; parts of it were visible in places in the form of a thin layer inside the adventitia in the outer wall of the sac. A number of small, endothelialized fissures without contents were also present around the upper pole of the sac.

The sac compressed the arterial lumen to about 1 mm, and was filled by a thrombus. For a length of about 5 mm from the upper pole of the sac, the intima around the thrombosed vessel lumen showed slight, diffuse thickening, and was necrotic. The inner layers of the fibrosed media had a low content of muscle cells and in the lower part of the resected segment, the entire media was necrotic; in this region, a rupture of the media, the size of a pin's head, was present between the thrombosed arterial lumen and the sac. There were no indications that the sac had contained blood. None of the microscopic features



suggested that a communication between a free arterial lumen and the cystic formation had been present at any time; the rupture was, in all probability, secondary.

The postoperative course was uneventful. At follow-up examination 18 months later the patient was asymptomatic and had a normal pulse in the dorsalis pedis artery. Angiography showed an ordinary blood flow through the femoral artery (Fig. 1b).

Discussion

The present case seems to be most closely related to the group of cases with mucinous, intramural cystic degeneration of the popliteal artery, recently described by HIERTONN, LINDBERG & ROB and HIERTONN & LINDBERG. The mucus-filled sac in their cases definitely lay between the media and adventitia. In the present case, it is true that the cystic formation produced a marked bulge in the adventitia, and laterally was partly bordered by it, but obvious splitting of the outermost layer of the media was present, particularly at the upper pole of the sac. The process might consequently have arisen from degeneration of the media and could thus be described as an intramural dissecting aneurysm. The

features as a whole nevertheless differed considerably from the intramural dissecting aneurysms described in the literature which, for example, all contained blood, or showed definite signs of the presence of bloody contents at an earlier stage, i. e. intramural haematomas. (As has often been stressed, the term aneurysm is inadequate in this connexion, since it should be used only to denote circumscribed dilatation of the artery in which all the layers of the wall are included.)

It is exceedingly difficult in the present case to determine to what extent the necrosis of the media is to be regarded as primary and to what extent secondary. Secondary necrosis seems most probable in the segment of the vessel in which the arterial lumen was most compressed and was also occluded by a thrombus; the media between the cystic formation and the vessel lumen in this region was completely necrotic. No necrosis was present in the media bordering on the cystic formation in the proximal parts of the vessel and there is therefore no conclusive proof that necrosis of the media was the primary pathogenetic factor. Rupture of the vasa vasorum can, in all probability, be ruled out as a pathogenetic factor, since no indications existed that the mucous sac had contained blood.

The case described by ATKINS & KEY, in which a cystic formation was present in the adventitia of the left external iliac artery, most resembles those previously described. Microscopic examination showed it to be 'a typical ganglion containing myxomatous tissue'. Unfortunately, no detailed account was given of the patho-anatomic features in this case, which prevents any further comparison with the present case, or with those described by HIERTONN et coll. Another essentially similar case was reported by PATEL et coll.

With respect to the changes in the media in so-called dissecting aneurysm of the aorta — in this connexion applying to the pathologic processes first described by GSELL and by ERDHEIM — IRA GORE (1952, 1953) used the term 'idiopathic medial degeneration'. As far as the special group of cases now in question is concerned, the term mucinous cystic dissecting intramural degeneration of the popliteal artery seems to be the more adequate. Strictly speaking, even a cystic formation between the media and adventitia, of the kind described by HIERTONN et coll., can in fact be denoted as dissecting.

The aetiology cannot be established with certainty. LINDBOM's investigations in particular have shown that the segment of the popliteal artery below the adductor canal is exposed to considerable mechanical stress where repeated minor trauma may give rise to degenerative cystic changes in the vessel walls.

The present case, apart from the theoretical aspects of the histologic picture, has interesting features from the clinical point of view. This

applies particularly to the arteriographic appearances at the actual occlusion. HIERTONN et coll. published an arteriogram from one of their cases (Case 1) showing localized stenosis of the popliteal artery seen as a short, regular, rounded impression in the vessel lumen. As may be inferred from Fig. 1a, the present case had a similar arteriographic appearance of regular compression of the arterial lumen from one side at the distal aspect of the occlusion. The appearances of the lumen proximal to the occlusion could not, on the other hand, be distinguished from those in arteriosclerotic or other more common stenotic changes. The arterial branches given off from the proximal region of the occlusion had a stretched, arched course. Thus, changes of the 'mucinous cystic dissecting intramural degeneration of the popliteal artery' type may present fairly characteristic arteriographic appearances indicative of an expansive process in the actual vessel wall.

SUMMARY

An account is given of a case of cystic degeneration of the popliteal artery, resembling the type described earlier by HIERTONN, LINDBERG & ROB with certain features suggesting that changes of this type should be denoted as mucinous cystic dissecting intramural degeneration of the popliteal artery (LINDBERG). The characteristic features are discussed.

ZUSAMMENFASSUNG

Es wird über einen Fall von cystischer Degeneration der arteria poplitea berichtet, der dem Typ gleicht, der schon früher von HIERTONN, LINDBERG u. ROB beschrieben worden ist. Das Bild dieses Types lässt vermuten, dass die Veränderungen eine schleimige, cystisch-dissekierende, intermurale Degeneration der Arteria poplitea darstellen (LINDBERG). Die charakteristischen Eigenschaften werden diskutiert.

RÉSUMÉ

Les auteurs rapportent un cas de dégénérescence kystique de l'artère poplitée, ressemblant au type déjà décrit par HIERTONN, LINDBERG et ROB, mais avec certaines particularités qui font penser que les lésions de ce type devraient être appelées dégénérescence intramurale disséquante kystique muqueuse de l'artère poplitée (LINDBERG). Ses traits caractéristiques sont examinés.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: ERIC SELANDER), LÄNSLASARETTET, MÖLNDAL, SWEDEN

ROENTGEN FINDINGS IN A CASE OF PHAEOCHROMOCYTOMA

by

P. Elfvin

The value of aortography in examining the suprarenal glands and the possible differential diagnostic importance of the method in suprarenal tumours have been pointed out by EDSMAN (1957) and AHLBÄCK (1958). Relatively few cases of suprarenal tumours demonstrated by aortography, however, have been published, a survey of the literature giving a total of 22 histologically verified cases. NELSON has reported one case of malignant cortical tumour, WALTER and GOODWIN one case of phaeochromocytoma, DAHL-IVERSEN two phaeochromocytomas in one case, DENSTAD two cases of malignant neurinoma, and SÜSSE & RADKE two cases of phaeochromocytoma and one case of cortical adenoma. In addition, AHLBÄCK has described two cases of cortical carcinoma and one case of cortical adenoma, FAGERBERG three cases of cortical carcinoma and, finally, EDSMAN three cases of phaeochromocytoma, two cases of malignant cortical adenoma, one case of benignant cortical adenoma, one case of malignant neuroblastoma, and one case of suprarenal tumour not histologically verified.

A study of these cases shows three main angiographic types of suprarenal tumours: 1) benign adenomas with a diffuse accumulation of

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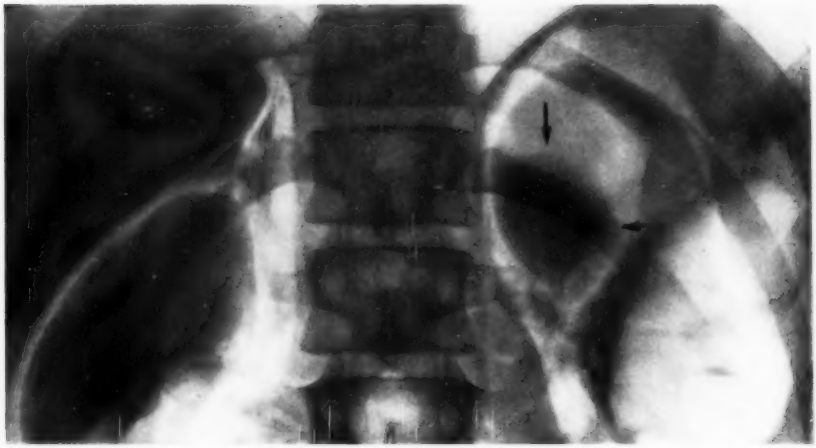

Fig. 1. Retroperitoneal pneumography. Right adrenal normal. Rounded dense portion above left hilum.

contrast medium in the tumour during the capillary phase resembling that in normal suprarenal glands but no abnormal arteries. 2) malignant adenomas, malignant neurinomas, and neuroblastoma with tumour vessels and arterio-venous fistulas and more or less irregular accumulations of contrast medium in the growth, and, 3) phaeochromocytomas. Two of the latter were avascular cystic tumours causing only displacement of vessels; the remaining six had tumour vessels without arteriovenous fistulas and showed diffuse accumulation of contrast medium.

It is obvious that a large case material of these rare tumours can hardly be collected in one hospital. With due regard, therefore, to the angiographic possibilities in the differential diagnosis, the publication of a single verified case may appear to be justified.

Male, aged 19, with a four months' history of fatigue and sweating. On examination there was increased blood pressure of the continuous type, which to begin with was regarded as juvenile hypertonia. Analyses of the urine showed, however, increased excretion of blood pressure increasing substances, suggesting the presence of a phaeochromocytoma.

At urography nothing abnormal was found. At retroperitoneal pneumography with 1 000 ml of oxygen (Fig. 1) the right adrenal gland was normal. A rounded soft tissue opacity was noted in the front of the left kidney above the hilum. This was supposed to be the enlarged adrenal. Aortography via the femoral artery was then performed, the tip of the catheter lying at the level of Th 12 (Fig. 2). During the arterial phase (Fig. 2a) a branch originating from the left renal artery close to the aorta was seen running obliquely upwards and outwards to the soft tissue opacity above the hilum where it divided into numerous tumour vessels. In the next view, 1 sec later (Fig. 2b)

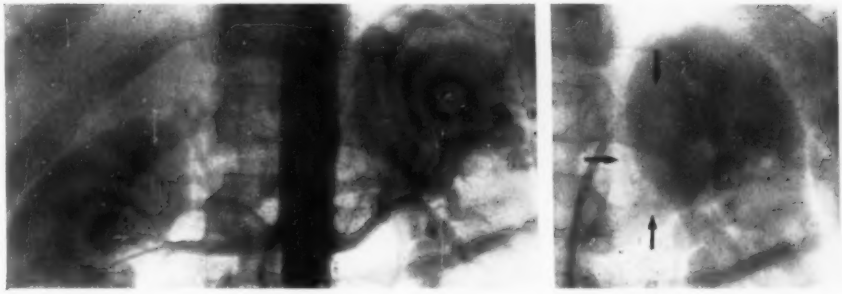

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Fig. 2. Aortography. a) Arterial phase. Right adrenal normal. b) Capillary phase, left side. Contrast-filling of phaeochromocytoma above hilum.

contrast filling of a rounded formation, 4 cm in diameter, lying over the kidney with its margin slightly medial to the latter, was obtained. The structure was granular, resembling the early filling phase of a normal adrenal with numerous small, almost ring-shaped collections of contrast medium. During the next three seconds the opacity of the contrast medium had become more homogenous and lost its structural appearance. The right adrenal was normal. A diagnosis of a phaeochromocytoma was made.

At operation an infiltrated adrenal gland weighing 34 grams was removed and subsequently confirmed histologically as being a phaeochromocytoma. As an immediate sequel of the ligation of the vessels of the tumour, the patient's blood pressure decreased from 170 to 110 and has since become stabilized at 120 to 125 mm Hg.

In this case the correct diagnosis was thus obtained by aortography. The angiographic appearance was in good accordance with that found in the six published cases of solid phaeochromocytoma, rich in vessels. Our findings during the arterial phase were: Tumour vessels without arterio-venous fistulas and moderate diffuse contrast accumulation in the tumour.

SUMMARY

A case of phaeochromocytoma diagnosed by aortography is described.

ZUSAMMENFASSUNG

Ein Phaeochromozytomfall, welcher mit Hilfe einer Aortographie diagnostiziert worden ist, wird beschrieben.

RÉSUMÉ

Présentation d'un cas de phéochromocytome diagnostiqué par aortographie.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: PROF. ERIK LINDGREN), SERAFIMER-LASARETTET, STOCKHOLM, SWEDEN

AUTOTOMOGRAPHY OF THE FOURTH VENTRICLE AND THE FLOOR OF THE THIRD VENTRICLE

by

J. Schvarcz

Lateral views of the skull obtained during lumbar encephalography show the air-containing mastoid cells of the two sides projected wholly or partly — depending upon their size — over the fastigium and plexus chorioideus as well as over the floor of the posterior part of the fourth ventricle and the foramen of Magendie. The details of these structures are consequently difficult to interpret.

The employment of tomography is necessary to eliminate the superimposition of two different air-containing systems and define one of them clearly. A modified tomographic method and its theoretical basis was described by ZIEDSES DES PLANTES in 1950. During the course of ventriculography, and after the patient had been made to execute a 'somersault', he rotated the patient's head manually from side to side; by means of the tomographic effect produced he obtained clear lateral views of the fourth ventricle, which was sharply projected against the blurred outline of the overlying mastoid cells.

A so-called autotomographic method, based upon the principles of ZIEDSES DES PLANTES, has been in use in our department for several years. It has the advantage that the rotation of the head even when the

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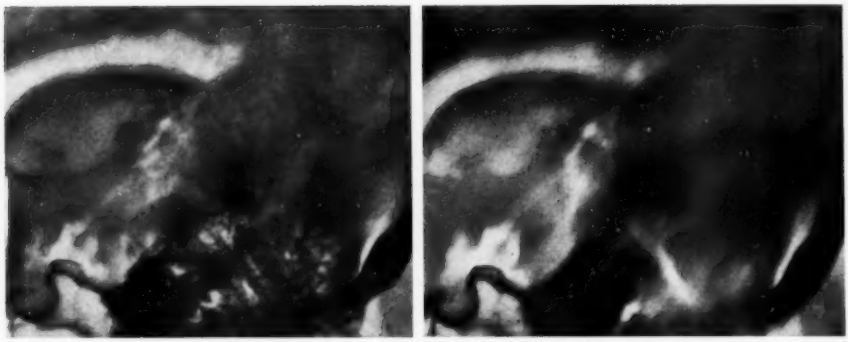

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Fig. 1. a) Conventional lateral view. The fastigium and chorioid plexus of the fourth ventricle not visible; other details of the fourth ventricle only just seen. b) Autotomographic view. The entire fourth ventricle and the canalis Magendie are clearly outlined.

patient is under anesthesia may be carried out almost without any direct intervention by the examiner, thereby considerably reducing the radiation hazards. By this procedure we have obtained sharp lateral views of the fourth ventricle and canalis Magendie at lumbar encephalography.

Since autotomography is nowadays in our department an integral part of lumbar encephalography, the patient sits, as for this examination, upon a specially constructed chair with the head supported by a cushion suspended on the vertical skull stand. As soon as it is evident in a lateral

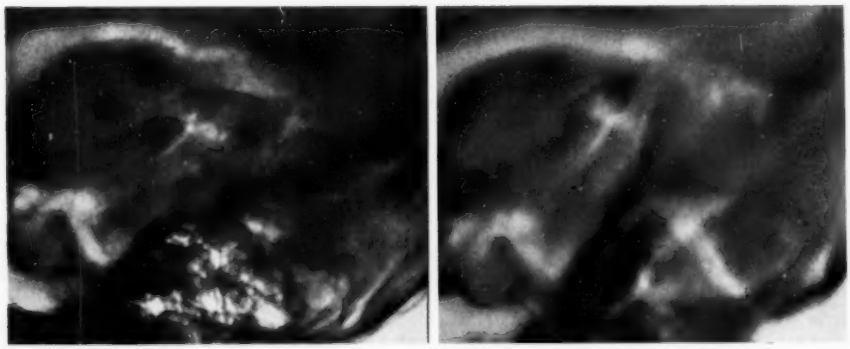

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Fig. 2. a) Conventional lateral view at encephalography. The fourth ventricle is not seen due to superimposition of the mastoid cells. b) Autotomographic view. Complete demonstration of the fourth ventricle and the canalis Magendie.

Fig. 3. Positioning of a patient, under general anesthesia, for the autotomographic lateral view. The examiner's hands hold the reins.

film that the air injected has entered the ventricular system, preparations are made for a further lateral film centered over the fourth ventricle, the surface marking of which lies about 1 cm behind the pinna of the ear. The examiner then demonstrates the proper procedure by rotating the patient's head manually on the axis of the odontoid process and instructs the patient to carry out the same movement himself when directed to do so. After the slow injection of 5 ml of air the patient at a given signal rotates his head and the autotomographic lateral view is taken with an exposure time of 2.5 to 3 seconds.

Fig. 1a is a conventional lateral view in the sitting position in which the fourth ventricle and a part of the aqueduct can be identified only with difficulty. Fig. 1b shows the result of autotomography at the same examination; the canalis Magendie is sharply defined as a 2 mm wide streak of air connecting the cisterna magna with the fourth ventricle. The latter is clearly shown, as is the chorioid plexus which bulges in from behind. In the conventional lateral view reproduced in Fig. 2a the fourth ventricle cannot be seen, but in the same view with autotomography (Fig. 2b) both the fourth ventricle and, in this case, the wide canalis Magendie are well outlined.

The procedure of autotomography in patients under general anes-

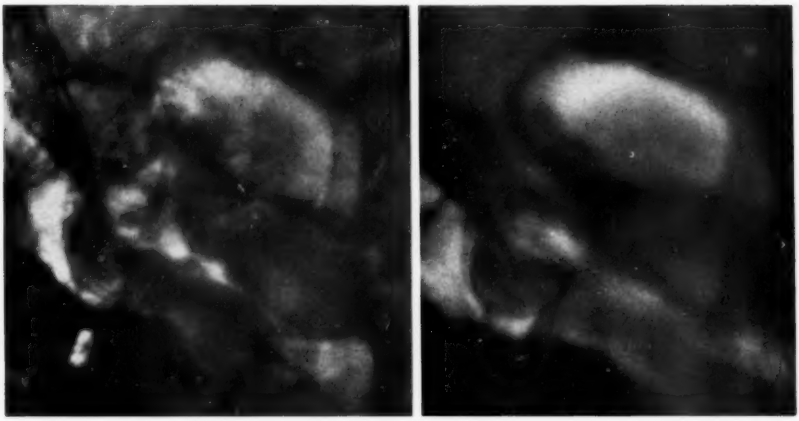

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Fig. 4. a) Conventional lateral view in axial position. Suprasellar expanding lesion. Only the anterior part of the floor of the third ventricle is visible, because of superimposition of cisternal air. b) Autotomographic lateral view in same position. Upward displacement of floor of third ventricle and flattening of its recesses now defined.

thesia is illustrated in Fig. 3. A gauze roll bandage is attached to each side of the Glisson sling which supports the head. The examiner stands about 3 meters behind the patient and, using the gauze strips as reins, slowly rotates the head from side to side during the exposure.

At the pneumoencephalographic examination of suprasellar expanding processes it is not unusual for a displacement of the anterior part of the third ventricle to be obscured in the axial lateral films since air in the cisterns around the sella turcica and in the sylvian fissure is generally projected over the area. It used to be our practice to take the axial lateral films the day after the examination as it was found that most of the air in the cisterns and sylvian fissure had then been absorbed and the anterior part of the third ventricle could be examined. This method of depicting this region has now been replaced in our department by autotomography in the axial lateral projection in conjunction with a similar conventional view. The technique used in these cases, both in conscious patients and those under general anesthesia, is the same as that described for the autotomographic examination of the fourth ventricle. Fig. 4 shows that the displacement of the anterior portion of the third ventricle is more clearly demonstrated in the autotomographic than in the conventional view.

SUMMARY

A modified tomographic method for the examination of the fourth ventricle and the anterior part of the third ventricle is described.

ZUSAMMENFASSUNG

Eine modifizierte tomographische Methode für die Untersuchung des 4. Ventrikels und des vorderen Abschnittes des 3. Ventrikels wird beschrieben.

RÉSUMÉ

Description d'une méthode tomographique modifiée pour l'examen du quatrième ventricule et de la partie antérieure du troisième ventricule.

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FROM THE PHYSICS DEPARTMENT (CHIEF PHYSICIST: L. A. W. KEMP) THE LONDON HOSPITAL, WHITECHAPEL, LONDON, ENGLAND

PHYSICAL ASPECTS OF ROENTGEN THERAPY USING WEDGE FILTERS

III. The effect on wedge fields of variations in kV and others factors

by

M. Cohen and *J. E. Burns*

In parts I and II of this paper (COHEN 1959) some new copper wedge-filters were described, and an analysis presented of the effects of changes in the various factors concerned with the isodose curves of an individual wedge, and with the arrangement of two wedges and a normal (non-wedge) field in a three-field treatment array. It was, however, assumed throughout the previous discussions that the incident radiation was maintained at the specified quality, i. e. 250 kV, clinical filtration 1 mm Cu + 1 mm Al, HVL 1.74 mm Cu, and that no alterations were made in the basic geometry of the wedge applicator.

Frequently, however, it is necessary to make some change in these factors, when, for example, it is desired to utilize published data in circumstances other than those specified. Even within a given hospital, wedge filters normally used with a particular roentgen machine may need to be transferred (for example, in an emergency) to another type of set. It is useful, therefore, to study the effects of beam quality and of various geometrical factors on wedge field dosimetry.

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Effect of incident beam quality

Throughout this paper the 'incident beam' will be taken to mean the beam of roentgen-rays incident on the wedge filter, not the beam which has passed through the wedge and is incident on the skin.

There are two basic approaches to the study of variations in the incident beam quality: (1) the changes needed in the design of the wedge filter may be determined so that a dose distribution previously obtained at beam quality *A* is reproduced at quality *B*, or (2) the change in dose distribution may be determined when a given wedge filter, designed for use with radiation of quality *A*, is actually used with radiation of quality *B*.

Only the second situation will be considered in the present paper. In the case of the dose distribution associated with a single wedge field, the changes which need to be studied may arise from variations in the kV—clinical filter combination (e. g. between different X-ray sets), the half-value layer remaining constant, or from variations in the HVL of the incident beam due to changes in clinical filtration for a given machine working at a fixed kV. In addition, the effect of the above variations on the dose distribution in a 3-field array has to be considered, bearing in mind that any change in the incident beam quality will usually apply to the non-wedge as well as to the wedge fields.

In order to elucidate these questions, detailed measurements were made with the 6 × 15 cm wedge applicator, and more abbreviated measurements with the other three applicators. (For details of the 4 wedge applicators, see part I.) The radiation conditions used are set out in

Table 1

Set	kV	Filter (mm Cu)*	HVL (mm Cu)
Watson XT1	260**	0.25	1.05
		0.5	1.35
		1.0	1.85
		1.5	2.15
		2.0	2.40
Watson XT1	250	1.0	1.74
Maximar	220	0.25	0.77
		0.5	1.07
		1.0	1.58
		1.5	1.93
		2.0	2.15

* Plus 1.0 mm Al in each case. ** The use of 260 kV, with a nominally 250 kV machine, arose from the fact that an unsuspected fault occurred in the pre-reading kV meter, which was not discovered and remedied until after the present experiments had been completed. The HVL's quoted in the table were all measured under the same experimental conditions.

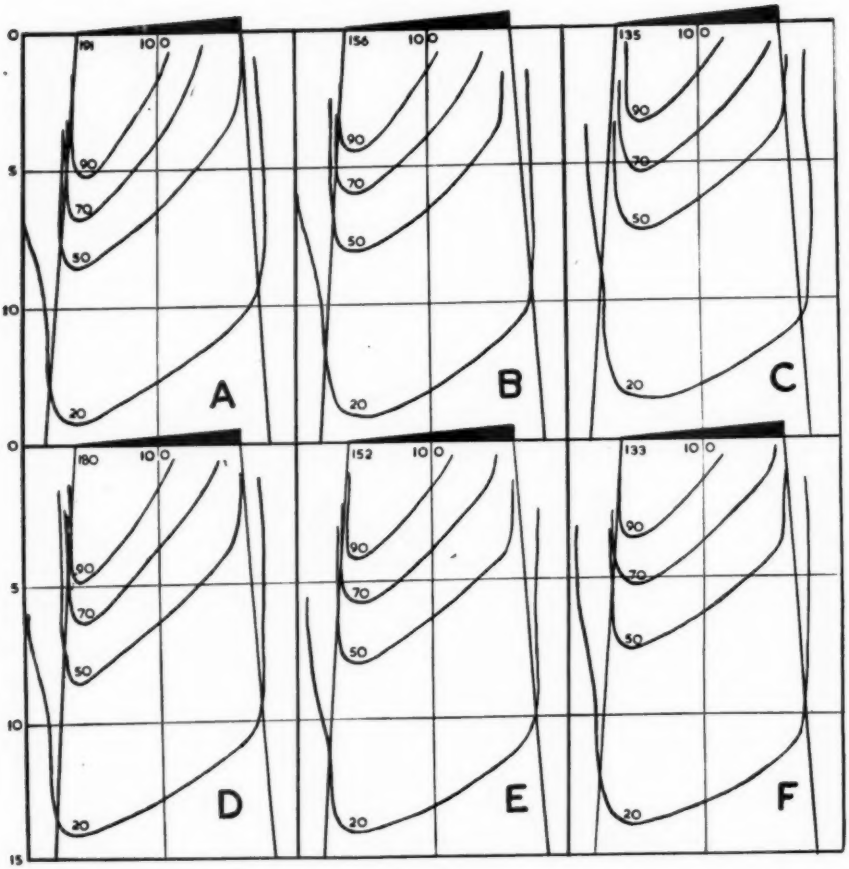

Fig. 1. Measured isodose curves and maximum percentage skin doses for 6 × 15 cm wedge with incident radiation of different qualities.

	kVp	Filter, mm Cu	HVL mm Cu
A	220	0.5	1.07
B	220	1.0	1.58
C	220	2.0	2.15
D	260	0.5	1.35
E	260	1.0	1.85
F	260	2.0	2.40

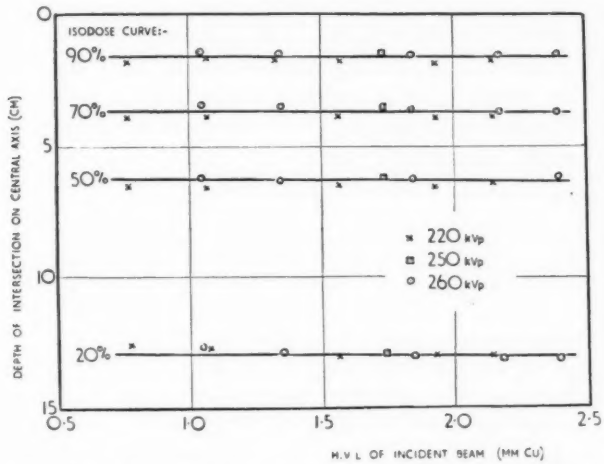

Diagram 1. Measured depth of intersection on central axis of selected isodose curves vs incident-beam quality, for 6 × 15 cm wedge.

Table 1. To obtain the maximum of useful information with a minimum of labour, the measurements for each kV—clinical filter combination were reduced to the following:

1. Central axis measurements in the first 2 cm depth, to establish the central surface dose by extrapolation;

2. Plotting of the 90 %, 70 %, 50 % and 20 % isodose curves;

3. Measurements near the surface along the line of the 'noses' of the isodose line, to establish (by extrapolation) the maximum percentage surface dose;

4. Measurement of absolute dose-rate at a convenient point on the central axis.

Isodose charts, with the four selected lines, for six incident beam qualities, are shown for the 6 × 15 cm wedge in Fig. 1. An indication of the maximum percentage surface dose, opposite the thin edge of the wedge, is also included in each chart. The curves shown, together with others not included in the figure, can, of course, be used as they stand as a basis for interpolating isodose charts for other radiation qualities, but such interpolation is likely to be unreliable unless some guiding principles are available. This is particularly the case with the 3 wedges other than 6 × 15 cm, for which the experimental evidence is less com-

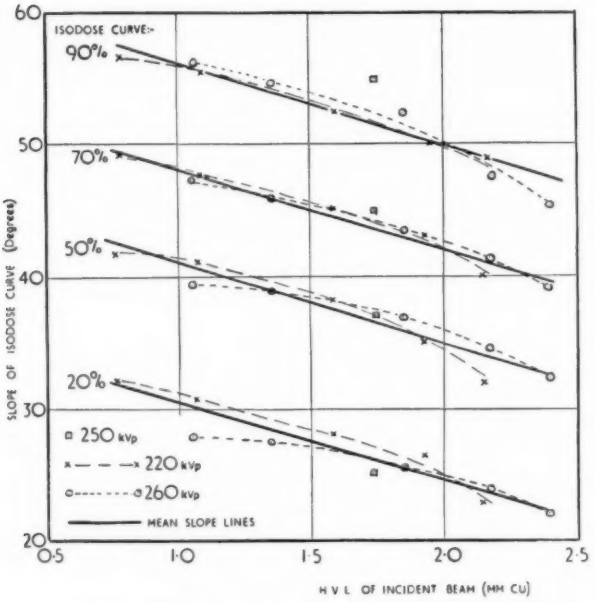

Diagram 2. Measured slope of selected isodose curves vs incident-beam quality, for 6 × 15 cm wedge. The heavy parallel lines are the mean slope lines (see text).

plete. An analysis has therefore been carried out, with the object of establishing a simple method of deducing the isodose curves of any of the wedges with an incident beam of any quality within the range studied. The minimum information necessary for the construction of a wedge isodose chart is as follows:

central axis percentage depth doses,
isodose curve slopes,
depths of the isodose 'noses', and,
the maximum percentage surface dose.

The analysis has accordingly been made in these terms.

Central axis percentage depth doses. Diagram 1 indicates that, for the 6 × 15 cm wedge, the central axis percentage depth doses are virtually independent of the incident beam quality over the entire range studied, i. e. 0.77 to 2.40 mm Cu HVL. The small differences between the depths

of intersection of the 4 selected isodose lines, for 220 kV and 260 kV, are of doubtful physical significance, probably arising from a systematic difference in the experimental arrangement adopted with the two roentgen machines. If the data of Diagram 1 are cross-plotted as actual percentage depth-dose curves for a given HVL, it is found that the variation (expressed as a percentage of the mean dose at a depth) is less than $\pm$ 2 % at all depths, and indeed less than $\pm$ 1 % in the important range 5 to 10 cm. This variation may be neglected for clinical purposes. The results for the other 3 wedges indicate that the constancy of central axis percentage depth doses is generally true: again a slight difference in the values for 220 kV and 260 kV may be ignored for clinical purposes.

Wedge isodose slopes and slope lines. The slope of a wedge isodose line was defined in part I as the angle which the tangent to the curve, at the central axis, makes with the applicator face, i. e. 90° minus the angle to the central axis itself. The variation with incident beam quality in the slope of the 4 selected isodose lines, is shown in Diagram 2 for the 6 $\times$ 15 cm wedge. As might be expected, it is seen that the slope decreases with increasing hardness of the incident beam, i. e. the effectiveness of a given wedge filter diminishes for harder radiation. There is a small systematic difference between the results for 220 kV and 260 kV, the rate of change of isodose slope being greater for the lower kV. This is true also for the 6 $\times$ 8 cm wedge, but for the 5 $\times$ 5 cm wedge the rates of change are approximately equal for both kV's, and for the 8 $\times$ 10 cm wedge the higher kV shows a greater rate of change of slope. The differences involved are, however, comparatively small, so that by drawing a mean curve through all the experimental points the maximum error introduced is only about 2° in 30° (for the lower isodose curves), while the error in the important region represented by the 50 % to 90 % isodoses is less than 1° in 35 to 55°. In view of the difficulty in drawing an accurate tangent to an isodose curve, such errors are of doubtful significance.

Two further simplifying approximations may now be made. Firstly, the mean curves just referred to may be replaced by straight lines, which will be termed 'slope' lines. These lines are nearly, but not exactly, parallel (the steeper lines being those referring to isodoses nearer the surface). As a second approximation, therefore, the slope lines may be rendered parallel and inclined to the x-axis by an angle given by the average of the inclinations of the 90 %, 70 % and 50 % slope lines (representing the important region of field-overlap in a combined field treatment). The parallel lines thus obtained are shown in Diagram 2, from which it is seen that the maximum error involved, relative to the experimental points, remains less than 3°, while the average error in the case of the 50 % and higher isodoses remains less than 1°.

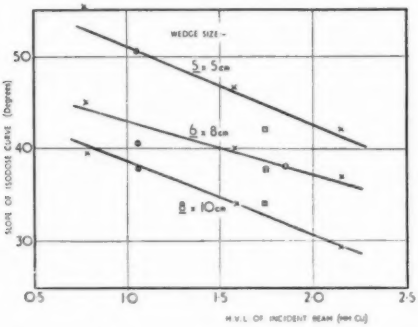

Diagram 3. Measured slope of 50 % isodose curve vs incident-beam quality, and mean slope line, for 5×5, 6×8 and 8×10 cm wedges.

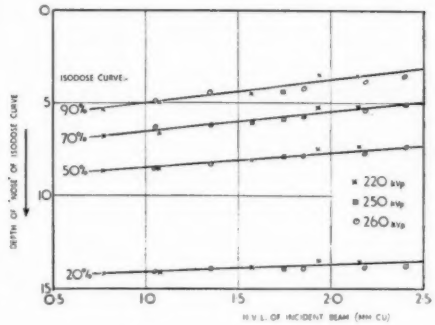

Diagram 4. Measured depth of 'nose' of isodose curve vs incident-beam quality, for 6×15 cm wedge.

The constant inclination of the slope lines for a given wedge may conveniently be represented by a slope coefficient (degrees per mm Cu change in HVL). Clearly, by applying the slope coefficient to the known slope of the isodose curves at a single HVL, the slopes of the isodose curves at any other HVL (within the range covered) may be calculated. The single HVL chosen as the reference quality need not necessarily be a quality at which experimental observations have been made: indeed it may be more convenient to take an HVL in the middle of the range (1.50 mm Cu) and to obtain the slopes at this quality from the slope lines drawn in Diagram 2, the slopes of those isodose curves not given in the diagram being found by graphical interpolation and extrapolation.

Curves similar to those in Diagram 2 have been prepared for the other 3 wedges, although with somewhat less certainty as they are based on fewer experimental points. However, apart from the difference already mentioned in the relationship between 220 kV and 260 kV, the conclusions reached for the 6×15 cm wedge apply to the others also, although the slope coefficient is different for each wedge. The slope lines of the other 3 wedges, for the 50 % isodose curve in each case, are shown in Diagram 3. (The slope lines shown in this diagram are not, of course, the best straight lines through the experimental points indicated, but the slope lines of mean inclination as determined by the procedure described.) It is seen that the greatest spread of the experimental points occurred for the 5×5 cm wedge (the experimental difficulties increasing as the field size decreased), amounting to about $\pm 2°$ (in 40 to 55°) in the case of the 50 % isodose curve.

Table 2

Data for reference quality (1.5 mm Cu HVL) and coefficients for construction of isodose charts

Wedge size	5 × 5 cm			6 × 8 cm			6 × 15 cm			8 × 10 cm		
Isodose curve %	Depth on C. A. (cm)	'Nose' depth (cm)	Slope (deg)	Depth on C. A. (cm)	'Nose' depth (cm)	Slope (deg)	Depth on C. A. (cm)	'Nose' depth (cm)	Slope (deg)	Depth on C. A. (cm)	'Nose' depth (cm)	Slope (deg)
100	0	3.5	61	0	3.7	58	0	3.7	57.5	0	4.5	58
90	1.4	4.1	58	1.6	4.5	54	1.6	4.5	53	1.6	5.2	51.5
80	2.2	4.8	55	2.6	5.2	50	2.6	5.2	49	2.8	5.9	46
70	3.2	5.5	52.5	3.6	6.0	47	3.7	6.0	45	3.9	6.7	41.5
60	4.1	6.4	49.5	4.7	6.8	43.5	4.8	6.9	41.5	5.1	7.7	38
50	5.3	7.3	46.5	6.0	8.0	40	6.3	8.1	38	6.4	8.8	34.5
40	6.7	8.6	43.5	7.5	9.3	37	7.9	9.4	34.5	8.1	10.0	31
30	8.5	10.2	41	9.6	11.1	33.5	10.0	11.3	31	10.3	11.9	28.5
20	11.0	12.7	38	12.2	13.6	30.5	12.9	13.9	27.5	13.1	14.6	26
10	15.4	16.9	35	16.6	17.8	28	17.8	18.5	24.5	17.9	19.1	24
Coefficient (per mm Cu increase in HVL)	0	–0.9	–8.9	0	–0.9	–5.6	0	–1.0	–6.0	0	–1.4	–8.0

Depth of isodose 'noses'. The analysis so far described enables the tangents at the central axis to be drawn for any desired incident beam quality. However, it is also necessary to determine the extent to which an isodose curve bends away from its tangent, and for this purpose a further point must be specified. The most convenient point is the point of maximum depth of the isodose curve, the so-called 'nose' of the curve. It is found experimentally that a straight line may be drawn through all the 'noses' on a wedge isodose chart, and that the position of this line is virtually independent of the incident beam quality. The line will be referred to as the 'nose line', along which the depth of each isodose 'nose' is measured. The point at which the nose line meets the surface is the point of maximum surface dose and occurs (again, independently of quality) at a distance from the field edge of approximately 0.1 of the width of the wedge.

In Diagram 4 isodose 'nose' depth is plotted against half-value-layer of the incident beam for the 6 × 15 cm wedge. It is seen that this depth varies only slowly with HVL, the relationship being linear and independent of kV. Similar, though less detailed, graphs for the other wedges confirm this result. Furthermore, the lines in Diagram 4 are approximately parallel, so that, as with the slope lines, they may be replaced by a set of parallel lines whose inclination is specified by a 'nose coefficient' obtained by averaging the inclinations of the 90, 70 and 50 % lines.

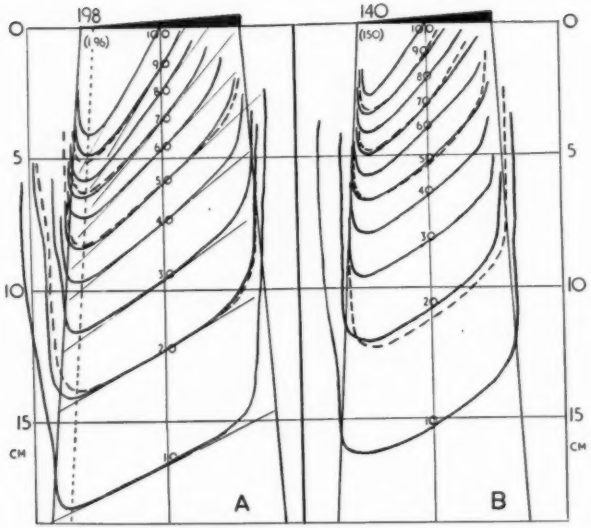

Fig. 2. Isodose curves (full lines) deduced from Table 2 (see text) and measured (broken lines). The measured maximum percentage skin dose is given in brackets. A — 6 × 8 cm wedge, HVL 1.05 mm Cu. B — 5 × 5 cm wedge, HVL 2.15 mm Cu.

Determination of isodose curves. The information contained in Diagrams 1—4 (and the corresponding graphs for the other wedges) is presented in convenient summary form in Table 2. The purpose of this table is to enable isodose curves to be drawn for any desired quality within the range considered. A half-value-layer of 1.50 mm Cu has been taken as the reference quality for which the basic information is provided; this was considered more convenient for calculation purposes than the original quality (1.74 mm Cu HVL) used in the work described in part I. The procedure for drawing isodose curves is as follows:

1. The intersections of the various isodose lines with the central axis are marked off.

2. The slope of each isodose curve is determined from Table 2, by adding or subtracting to the reference slopes given, an appropriate correction calculated from the slope coefficient (degrees per mm Cu change in HVL). The tangents to each isodose curve at the central axis are now constructed.

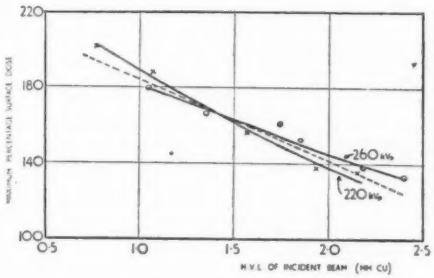

Diagram 5. Measured maximum percentage surface dose vs incident-beam quality, for 6 × 15 cm wedge. The broken line is the mean for both kV's.

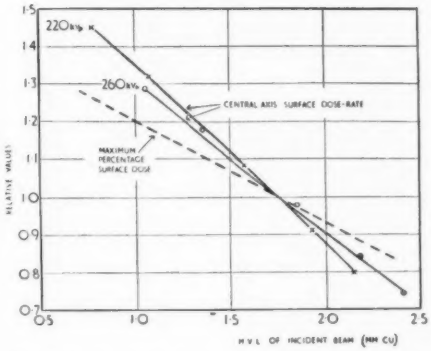

Diagram 6. Central axis surface dose-rate, normalized to 1.74 mm Cu HVL, vs incident-beam quality. The broken line represents the mean line of diagram 5 replotted on the same relative basis.

3. The nose line is drawn through a surface point distant 0.1 of the width of the wedge from one field edge. The nose line is approximately parallel to the geometrical edge of the beam, its exact divergence being given by the usual geometrical considerations for an FSD of 40 cm.

4. The depth of each isodose nose is determined from Table 2, by correcting the reference depth by means of the nose coefficient (cm per mm Cu change in HVL). These depths are marked off along the nose line.

5. The isodose curves are sketched in, on the thin side of the wedge; the curve on the thick side is obtained by utilizing the experimental observation that the divergence of an isodose curve from its tangent is approximately equal on both sides of the central axis.

6. Guidance as to the shape of the isodose curves near the beam edge on the thick side, and in the scatter bulges, is provided by Fig. 1 and by the full isodose curves given in part I. Errors in these sections of the curve are, however, comparatively unimportant in the final assessment of tumour dose in a 2- or 3-field array.

Two examples of isodose curves constructed by this method are shown in Fig. 2. For illustrative purposes qualities have been chosen which were actually measured during the investigation, but the full curves in this

Table 3

Maximum percentage surface dose at reference quality (1.5 mm Cu HVL) and coefficients for conversion to other qualities

Wedge size	Percentage surface dose (1.5 mm Cu HVL)	Coefficient (change per mm Cu increase in HVL)
5 × 5 cm	180	— 61
6 × 8 cm	173	— 55
6 × 15 cm	164	— 43
8 × 10 cm	180	— 45

figure have been drawn entirely on the basis of Table 2, as just described, while the broken curves were measured for the 90, 70, 50 and 20 % isodose lines. The method of constructing the isodose curves is indicated in Fig. 2 (A) (for the 6 × 8 cm wedge at an HVL of 1.05 mm Cu) by means of the tangents to each curve and the position of the nose line. It is seen that only in the lower isodose curves (e. g. 20 %) for the 5 × 5 cm wedge, Fig. 2 (B), is there any appreciable discrepancy between the constructed and measured curves. Since these lower isodose lines in any case fall outside the tumour area in any acceptable 2- or 3-field array, the discrepancy is of no practical importance. The significance of errors in the higher isodose curves may be estimated by plotting 'plateau curves' for typical field arrangements as described in part II. In this way it may be shown that the maximum error in the estimation of the mean percentage tumour dose is only 2 to 3 %, while the error in the assessment of the limits of the area of uniformity is usually 2 mm or less.

The time required to construct an isodose chart by the method indicated is about 10 minutes. Strictly speaking the method is applicable only within the ranges 220 to 260 kV, and 0.77 to 2.40 mm Cu HVL, but serious errors are unlikely to be introduced if these ranges are somewhat exceeded.

Maximum percentage surface dose. In parts I and II it was emphasized that the maximum percentage surface dose is of great importance in wedge field therapy using deep roentgen rays. In the case of individual wedge fields a limit of 170 % was set, allowing a reasonable number of 2- or 3-field arrays to be constructed such that the maximum skin dose lies within the permitted range of 1.3 to 1.4 times the mean tumour dose. If the incident beam is softer than 1.74 mm Cu HVL, to which the results of parts I and II specifically refer, the isodose curves are steeper (as discussed above) and, at the same time the maximum percentage surface dose is increased, and conversely for incident beams

softer than 1.74 mm Cu HVL. The relationship between the maximum percentage surface dose and the incident beam HVL is shown in Diagram 5 for the 6 × 15 cm wedge. As in Diagram 2 there is a small difference between the curves for 220 kV and 260 kV, but there is insufficient evidence from the other three wedges to indicate whether the difference is systematic or not. By replacing the two experimental curves with a single straight line (broken line in Diagram 5) the maximum error introduced is about 8 units of percentage, i. e. about 5 % of the actual surface dose. As in the analysis already described, by using a single straight line the calculation of the maximum percentage surface dose is reduced to the application of a coefficient to the value pertaining at the reference quality (1.5 mm Cu HVL). The latter is obtained from the broken line in Diagram 5, and from the corresponding lines for the other three wedges. The appropriate values and coefficients are given in Table 3.

Absolute surface dose-rate. The method just described enables the wedge isodose curves, and maximum percentage surface dose, to be deduced for any desired incident beam quality within the range considered. However, the absolute surface dose-rate, i. e. the dose-rate in r/minute at the central axis surface point, must always be found experimentally under the particular conditions to be used in practice. This is most easily done by measuring the dose-rate at a known depth along the central axis in a water (or equivalent) phantom, the surface dose-rate then being calculated by using the known percentage depth-dose at the point concerned. The latter may be assumed independent of incident beam quality, as already indicated in Diagram 1.

By way of illustration of the magnitude of the change in surface dose-rate which occurs with changing incident beam quality, the experimentally determined values for the 6 × 15 cm wedge are shown in Diagram 6. The values have been normalized to that obtained at 1.74 mm Cu HVL so that the actual dose-rates in r/minute may be calculated by reference to the approximate dose-rates quoted in Table 2 of part I, although, naturally, this information is relevant only to the therapy machines used by the authors.

An interesting comparison is made in Diagram 6, in that the mean curve of Diagram 5, relating to the maximum percentage surface dose, has been replotted on the same basis as that of the central axis surface dose-rate graph. It is seen that the latter quantity varies more rapidly with incident beam quality than does the maximum surface dose, the slope of the dose-rate graph being approximately 1.5 times the slope of the maximum dose graph. This has been found to be true for the other wedges also. The change in maximum percentage surface dose calculated

from Table 3 may therefore be used as an approximate check of the measured surface dose-rate, if the latter is determined at 2 or more incident beam qualities.

Effect of incident beam quality variations in field additions

The discussion so far has concerned the effect of incident beam quality on the individual wedge isodose chart. However, for practical therapy the 2- or 3-field combination rather than the individual field is of interest, as described in parts I and II. Strictly, the analysis given in part II should be re-worked for a number of incident radiation qualities, but in view of the enormous labour thus required a simpler approach has been made.

It has been shown above that, as compared with the 'basic' quality, if a softer incident beam is used with a given wedge filter, the isodose curves are steeper and the maximum percentage surface dose is increased. The same effect may be obtained by using a thicker wedge and retaining the original radiation quality. This state of affairs was, indeed, studied in some detail in part II, with particular reference to the 8 × 10 cm 'shallow' (40° wedge slope) and 'steep' (50° wedge slope) wedge. (As defined in part I, the wedge slope is the slope of the isodose curve which cuts the central axis at a depth equal to half the width of the wedge, i. e. at 4 cm depth in the case of an 8 × 10 cm wedge.) However, if the conclusions reached in part II are to be regarded as valid in the present context, it is necessary to show that the relationship between wedge slope and maximum percentage surface dose is the same in both situations. The evidence available on this point is limited, but indicates that — at least to a first approximation — the relationship is indeed similar.

The evidence just mentioned is as follows: by plotting wedge slope against incident beam quality for the 8 × 10 cm 'shallow' wedge, it may be shown (by a slight extrapolation) that a wedge slope of 50° is obtained with an incident beam of 0.6 mm Cu HVL. The graph (not reproduced) for this wedge corresponding to Diagram 5, i. e. maximum percentage surface dose *versus* HVL, may now be extrapolated to 0.6 mm Cu HVL, giving a maximum surface dose of 237 % for the 220 kV curve and 212 % for the 260 kV curve, the mean being 225 %. The measured value for the 8 × 10 cm 'steep' wedge at 1.74 mm Cu HVL is 217 %. Thus the maximum percentage surface dose corresponding to a 50° wedge slope in an 8 × 10 cm wedge is virtually the same whether the required slope is obtained by altering the quality of the incident beam or the thickness of the wedge filter itself.

Since the above conclusion was based on one wedge size only, it was essential to make an independent check. For this purpose the analytical

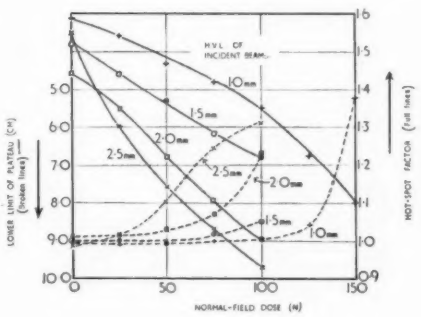

Diagram 7. Plateau limit (broken lines) and hot-spot factor (full lines) vs normal-field dose, for 6×8 cm wedge with incident beams of different HVL's. The wedge isodose charts were deduced from Tables 2 and 3 as described in the text. For fuller explanation of this type of graph, see part II.

method described in part II was followed through for a single set of conditions but using four different beam qualities. The chosen condition was: 6×8 cm wedge with 8×6 cm normal field. $\theta = 60°$, $s = 6$ cm, incident beam HVL's 1.0, 1.5, 2.0 and 2.5 mm Cu. To ensure self-consistency, the four wedge isodose charts were deduced by the method described above, using Table 2; while the contribution of the normal field was obtained from Section 2 of 'Central Axis Depth Dose Data' (1953) in the column for 50 cm², 50 cm FSD. (It is assumed that the incident beam quality is the same for both the normal and wedge fields. This is usually the case, except when the beam is hardened for the wedge fields only by employing an additional uniform filter incorporated within each wedge applicator. However, if the HVL is initially 1.5 mm Cu or above, the effect of a difference in quality between the fields will be negligible.)

At first sight it may appear that the softer incident beam, since it gives a higher maximum percentage surface dose, is bound to be inferior in a combined-field array, because it gives rise to a higher 'hot-spot factor' (i. e. maximum skin dose/mean tumour dose). However, the softer beam also produces steeper wedge isodose curves, and a pair of steep wedges give a combined distribution with a sharp 'negative gradient' which lends itself to the addition of a substantial contribution from the third (normal) field. The latter, by irradiating the tumour but not the region of maximum skin dose, reduces the hot-spot factor. Thus a soft incident beam must be associated with a large normal-field dose, and a hard incident beam with little or no normal-field dose, but neither is necessarily advantageous on that account alone. We therefore apply the criterion adopted in part II, i. e. we assess the depth of the lower limit of the 'plateau' when the normal-field dose is allowed to take whatever value is necessary to produce an arbitrary 'standard' hot-spot factor of 1.30.

The relevant curves for the example selected are given in Diagram 7, i. e. plateau depth and hot-spot factor versus normal-field dose, for the four HVL's specified. The wedge-field dose is assumed 100 throughout. Applying the criterion stated, it is seen that, while the normal-field dose to give HSF = 1.30 changes from 25 at 2.5 mm Cu HVL to 110 at 1.0 mm Cu HVL, the corresponding plateau depths all lie within the range 8.8 to 9.0 cm, i. e. there is nothing to choose between them. Certainly there does not appear to exist an 'optimum' beam quality. This result for the 6 × 8 cm wedge fits in with the conclusion formed in part II with respect to this wedge, viz. that the wedge slope at 1.74 mm Cu HVL was near optimum, if we assume that the 'optimum' wedge slope is not a single value but a range of values within which good results can be obtained by a suitable choice of the normal-field dose. (The evidence presented in part II was insufficient to allow this extension to be made.) However, it was also seen in part II that even the 'shallow' 8 × 10 cm wedge must be considered too steep at 1.74 mm Cu HVL, and it follows that any increase in the slope of this wedge, arising from the use of a softer incident beam, will be deleterious. Hence, in this case, it is advisable to use an incident beam with HVL at least 1.74 mm Cu, and if possible harder still. The utility of this wedge is then enhanced, and at the same time no disadvantage accrues with respect to the other wedges.

In the practical instance of the use of the 250 kV wedges on a 220 kV set, undoubtedly the most satisfactory solution is to harden the beam to 1.74 mm Cu HVL, by substituting a filter of approximately 1.25 mm Cu for the usual 0.5 mm Cu. All the published data will then be applicable without significant modification, the only disadvantages being the increase in the exposure times required and the necessity of changing the clinical filter on a set, which many regard as bad radiotherapeutic practice. It if is preferred to retain the lower clinical filtration, the normal-field contribution will need to be increased, in most cases from 50 to 100, and the percentage tumour dose will require re-calculation for all the arrangements to be used.

Effect of masking-down a wedge applicator

It has already been stated that at the London Hospital there are only four standard wedge applicators, viz. 5 × 5 cm, 6 × 8 cm, 6 × 15 cm and 8 × 10 cm. Apart from the occasional need for a larger wedge, such as 10 × 15 cm (to be discussed in part IV) there has been no general demand for other sizes, and the majority of lesions have been treated without undue difficulty, by one or other of the four available wedges.

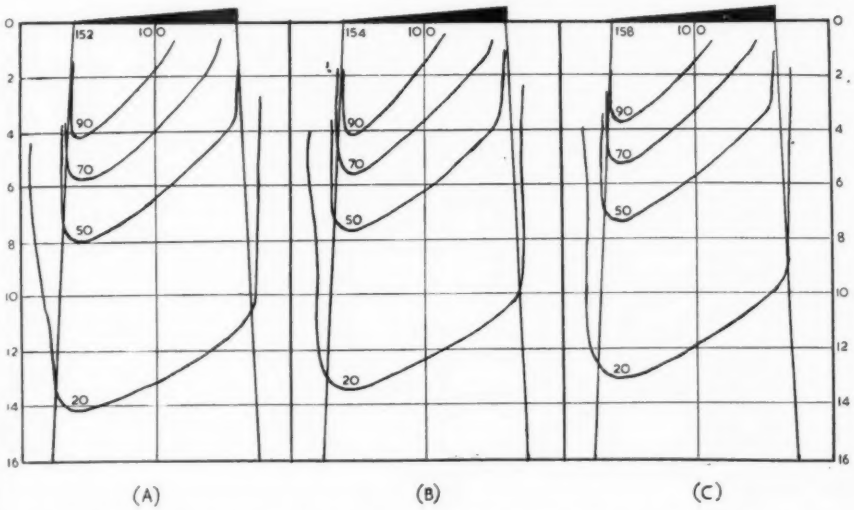

Fig. 3. Effect of masking-down a wedge field. Measured isodose curves (90, 70, 50 and 20 %) and maximum percentage skin dose. 6 × 15 cm applicator. A — field length 15 cm, B — field length 10 cm, C — field length 6 cm.

Sometimes, however, it is desired to shield a portion of the field to avoid irradiating a particular area or structure. In such cases it is extremely difficult to estimate the effect of the shield on the dose distribution and dose-rate: it depends not only on the area of the mask in relation to the whole, but also on its position with respect to the combined field isodose chart. A small lead shield, so placed that it cuts off only radiation which has passed through the thick side of one of the wedges, will have comparatively little influence on the dose distribution in the tumour region. On the other hand a shield of equal area but so placed that it intercepts radiation on the thin side of a wedge will alter the tumour dose quite radically. In such cases, in the absence of precise information as to the effect of the shield, it is better (and usually feasible) to replan the treatment completely, perhaps using smaller wedges, to avoid this particular difficulty.

One approach to the problem of a lead mask in a wedge field has been made by Worthley, Tooze, Brown and Fry (1955) using the optical integrator of Wheatley (1951). In the present work the experimental approach has been governed by the practical limitation just mentioned, i. e. the use of lead is avoided except where the shield either stretches across the whole width of the wedge or is confined to a small area on the

Table 4

Effect on central axis percentage depth doses and surface dose-rates of masking down normal and wedge fields

(6 × 15 cm applicator — 40 cm FSD — 1.85 mm Cu HVL)

Depth (cm)	Field type	Field length					
		15 cm		10 cm		6 cm	
		% D. D.	Ratio	% D. D.	Ratio	% D. D.	Ratio
3.0	Normal	77.0	1.00	75.0	0.98	74.7	0.97
	Wedge	77.0	1.00	75.9	0.99	73.5	0.96
5.0	Normal	59.8	1.00	57.1	0.96	55.4	0.93
	Wedge	60.0	1.00	58.7	0.98	55.4	0.92
7.0	Normal	44.7	1.00	42.3	0.95	40.7	0.91
	Wedge	46.0	1.00	44.2	0.96	41.0	0.89
10.0	Normal	29.1	1.00	27.0	0.93	25.2	0.87
	Wedge	30.8	1.00	28.6	0.93	25.8	0.84
12.0	Normal	21.6	1.00	19.9	0.92	18.0	0.83
	Wedge	23.5	1.00	21.6	0.92	19.2	0.82
15.0	Normal	13.7	1.00	12.3	0.90	11.1	0.81
	Wedge	15.6	1.00	14.1	0.91	11.8	0.76
Relative surface dose-rates:							
	Normal		1.00		0.96		0.89
	Wedge		1.00		0.97		0.89

thick side. The former is the more general case, particularly as it links up with the question of altering the length of a wedge applicator in the non-wedge direction. Some preliminary measurements have accordingly been made, but it is not suggested that the results offer more than a guide to the solution of this problem.

The measurements were made with the 6 × 15 cm wedge at 260 kV. 1 mm Cu filter (HVL 1.85 mm Cu). The field length, in the non-wedge direction, was reduced by means of lead strips, 3 mm thick, placed on both ends of the applicator face. Isodose curves, etc (as previously detailed), were measured for 2 reduced areas, of lengths 10 and 6 cm, and compared with those for the full area. The three isodose charts are shown side by side in Fig. 3, from which the following conclusions have been drawn:

1. The slope of the isodose curves increases slightly as the field length decreases. This effect is no doubt associated with the decreasing contribution from scattered radiation. However, the change appears so small as to be insignificant for clinical purposes.

2. The central axis percentage depth doses decrease as the field length diminishes, as one would expect for a decreasing field area. For purposes of estimating this decrease in any given instance it is important

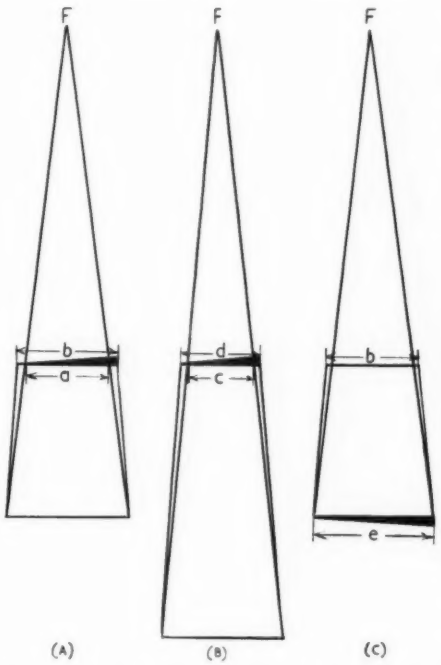

Fig. 4. Illustration of 'point-source' and actual dimensions of applicator back apertures. (See text for explanation of symbols.) A — Wedge at back aperture of 40 cm applicator, B — Wedge at back aperture of 50 cm applicator, C — Wedge at face of 40 cm applicator.

to know how the change compares with that obtained when the length of a similar non-wedge field is reduced, since information relating to the latter case is more likely to be readily available. Separate measurements of central axis depth doses were therefore made for each of the three field lengths considered, followed by measurements for identical non-wedge fields obtained by removing the wedge filter from the applicator. The percentage depth doses so measured, at selected depths, are given in Table 4, together with ratios obtained by expressing the values for 10 and 6 cm field lengths relative to the depth dose at the same depth for the 15 cm long field. It is seen that the relative fall in percentage depth dose with field length is practically the same for a wedge field as for the corresponding normal field, the discrepancy being less than 2 % except at two isolated points. A similar conclusion was reached on comparing the above wedge fields (40 cm FSD) with non-wedge fields of the same dimensions but at 50 cm FSD and with a slightly different beam quality (1.74 mm Cu HVL).

3. The central axis surface dose-rate (r/minute) falls with field area, and (making the same comparison as before) the magnitude of the fall is the same as would be obtained with similar normal fields (Table 4).

4. The maximum percentage surface dose increases as the field area falls, but the change is so small that it may be neglected for practical purposes.

Although it is difficult to generalize from experiments with only one wedge, tentatively it may be said that allowance may be made for

masking down a wedge applicator, or the insertion of a small lead shield lying approximately across the width of the wedge, by reducing the central axis surface dose-rate and the central axis percentage depth doses in the same ratio as would obtain with a similar non-wedge field, the slope of the isodose curves and the maximum percentage surface dose remaining unchanged. If direct measurements of suitable non-wedge fields are not available, the necessary data may be interpolated from standard tables of depth doses, e. g. 'Central Axis Depth Dose Data' (1953).

Effect of changes in FSD

It is frequently asked how the design of a wedge filter (e. g. as detailed in part I of this paper) should be modified if it is to be used in an applicator of 50 cm FSD instead of one of 40 cm FSD for which the filter was designed. After suitable modification of the wedge, it is required that the 50 cm FSD isodose curves will approximate closely to those published for an FSD of 40 cm. The feasibility of such a match is borne out by the work of OLIVER and KEMP (1952), who showed that the isodose curves obtained with wedge applicators of 30, 35 and 40 cm FSD were very similar. In that work, however, the wedge filter itself was placed on the face of the applicator, next to the skin, so that no adjustment of the dimensions of the wedge was needed. In more recent practice, however, the wedge is placed at the back aperture of the applicator (as in the present work) so that a change in wedge dimensions is necessary if the applicator FSD is altered.

In the Fulfield applicators described in part I and used throughout the present work, the wedge itself is at 27.5 cm from the focus, while the surface is at 40 cm. Consider the case of a 6×8 cm applicator. If the focus were a point, an aperture of 4.1×5.5 cm at 27.5 cm focal distance would serve to define the field size at 40 cm. In practice, however, the aperture needs to be somewhat larger (actually 4.5×6.0 cm) because of the finite size of the focus. Since in this argument we are concerned only with dimensions in the wedge direction, the width of the back aperture for a point source of radiation may be denoted by a, and the width for a source of a finite size by b (Fig. 4-A). If a 6×8 cm applicator of the same type but of 50 cm FSD is substituted, the back aperture (which remains at 27.5 cm focal distance) has a 'point-source' width of 3.3 cm, but a 'finite source' width of 4.0 cm (c and d respectively in Fig. 4-B).

It was seen in part I, (Fig. 1 and Table 1) that the sloping or stepped portion of a wedge filter occupies only the middle region of the aperture over which it is placed. On either side is a flat portion, of zero thickness

on the thin side and maximum thickness on the thick side. The part of the back aperture which corresponds to the difference between a and b, or between c and d, may be regarded as lying wholly in these flat portions of the wedge. The question now arises as to which ratio should be taken in modifying the step widths of a wedge in order to transfer it to an applicator of 50 cm FSD. There are three possibilities:

1. Change every step width in the ratio of the actual back apertures, i. e. d/b. This method ignores the fact that both b and d comprise a section associated with a point-source plus an addition which may be termed the 'penumbral' section.

2. Subtract the penumbral section (b—a) from every step width at 40 cm FSD, reduce the remainder in the geometrical ratio c/a, and finally add the new penumbral section (d—c) to each step width. This method, compared with method (1), may be said to apply a 'full penumbral correction'.

3. Apply a 'partial penumbral correction' by choosing step widths between those calculated by methods (1) and (2).

Wedges were constructed on principles (1) and (2) for a 6 × 8 cm applicator at 50 cm FSD and the isodose curves etc (as in previous experiments) compared with the original 40 cm FSD curves (1.85 mm Cu HVL). The three charts were found to be very similar, apart from a small increase in percentage depth-doses at the longer FSD, showing that a wedge may indeed be transferred to an applicator of different FSD. Detailed examination of the charts indicated that method (3) was correct, since the results of methods (1) and (2) deviated from the original in opposite senses, but (contrary to expectation) the curves obtained by method (1) were closer to the original than were those of method (2). Hence it may be said that, for practical purposes, the simple ratio of the widths of the back apertures may be taken as the correcting factor. If greater precision is required, one-third of the correction calculated by method (2) may be added.

Effect of change in wedge position

Finally, the possibility arises of changing the position of the wedge filter in an applicator of given FSD. For practical purposes this means placing the wedge on the front face of the applicator, as was formerly standard practice at the London Hospital (Ellis, Shanks, Kemp and

OLIVER 1950), and is still the case in some centres. This problem has not been investigated in any detail, but a single measurement may be quoted to illustrate the effect of a change based on the simplest possible calculation.

Following the result given above, in which the simple ratio d/b of method (1) was found to approximate well to the desired result, the transfer of the 6 × 8 cm wedge filter to the front of a 40 cm FSD applicator was carried out by modifying each step width in the ratio e/b (Fig. 4-C), where e is the field dimension at 40 cm, i. e. 6 cm in this case. The resulting isodose chart with the original superimposed, is shown in Fig. 5 (HVL 1.85 cm Cu). It is seen that, although the modified wedge gives slightly steeper isodose lines the differences are small enough to be neglected for clinical purposes. The maximum percentage surface dose is also greater when the wedge is mounted on the applicator face, the increase being somewhat larger than would be expected on the basis of the steepness of the isodose curves.

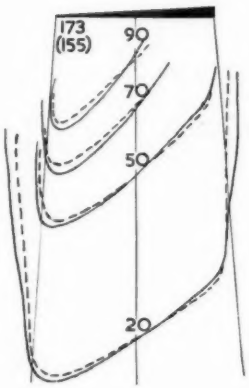

Fig. 5. Isodose curves for 6 × 8 cm wedge (HVL 1.85 mm Cu) in 40 cm FSD applicator, with wedge mounted on applicator face (full lines) and recess at back of applicator (broken lines). Maximum percentage surface dose for latter position of wedge within parentheses.

Conclusions

Experimental evidence is presented of the effect of changes in incident beam quality on the dose distributions associated with the wedge filters (designed for an HVL of 1.74 mm Cu) described in part I of this paper. A harder incident beam results in isodose curves of smaller slope, and a lower maximum percentage surface dose, but the central axis percentage depth doses remain virtually unchanged. For practical purposes the dose distribution for a given HVL is independent of the kV—filtration combination.

A method is described whereby (making certain simplifying assumptions) isodose curves may be deduced for an incident beam of any desired HVL (within, strictly, the range 0.77 to 2.40 mm Cu), for the 4 wedge sizes specified in part I. The method involves the specification of central axis percentage depth doses, slopes of isodose curves and depths of isodose 'noses' for a single reference quality (1.50 mm Cu HVL), together with correcting coefficients for other qualities. The maximum percentage surface dose may be deduced by a similar method. Isodose curves obtained by this means are shown to agree well with those measured experimentally at the same HVL.

The effect of changes in incident beam quality is also discussed with reference to the 2- and 3-field arrays described in parts I and II. In the case of the 6 × 8 cm wedge, it is shown that, provided that the contribution of the normal field is suitably adjusted, equivalent dose distributions may be obtained with incident beams of any HVL within the range 1.0 to 2.5 mm Cu. On the other hand, optimum use of the 8 × 10 cm wedge requires the use of radiation within the upper half of this range.

Preliminary experiments indicate that the effect of decreasing the length of a wedge field in the non-wedge direction, by masking with lead strips, is as follows: the slopes of the isodose curves, and the maximum percentage surface dose, are virtually unchanged, but the central axis percentage depth doses and the surface dose-rate are decreased in essentially the same ratio as occurs when the length of a comparable non-wedge field is similarly decreased.

When a wedge filter is transferred to an applicator of different FSD (e. g. 40 to 50 cm), satisfactory matching of the isodose charts, for clinical purposes, is obtained when the dimensions of the wedge are changed in the ratio of the widths of the back apertures of the two applicators. For even closer matching a small correction to the wedge dimensions may be made, based on a consideration of the 'point-source', as distinct from the actual dimensions of the back aperture. Similar considerations apply when the wedge filter is transferred from the back aperture to the face of an applicator.

SUMMARY

Experimental evidence is presented of the effect of changes in incident beam quality on the dose distributions associated with the wedge filters described in part I of this paper. A method is described whereby isodose curves may be deduced for an incident beam of any desired HVL. This involves the specification of central axis percentage depth doses, slopes of isodose curves and depths of isodose 'noses' for a single reference quality, together with correcting coefficients for other qualities. The maximum percentage surface dose may be deduced by a similar method. The effects of masking a wedge field with lead, of altering the FSD of the applicator, and of changing the position of the wedge, are also discussed.

ZUSAMMENFASSUNG

Es werden experimentelle Resultate beschrieben, die darauf hinweisen, dass die Qualität der einfallenden Strahlung die Dosisverteilung bei Anwendung von Keilfeldern wie im ersten Teil beschrieben wurde, ändert. Es wird eine Methode angegeben, mit welcher die Isodosen für eine einfallende Strahlung mit beliebiger Energie berechnet werden kann, wobei die relative Zentralachsen-Dosis, die Neigung der Isodosen und die Tiefe der Isodosen-»Nasen« für eine bestimmte Strahlenqualität zusammen mit anderen Korrektionskoeffizienten in die Rechnung eingehen. Die maximale Hautdosis kann in ähnlicher Weise berechnet werden. Die Wirkungen der Abschirmung eines Keilfeldes mit Blei, der Änderung der FHA (FSD) des Applicators und der Änderung der Keillage werden ebenfalls diskutiert.

RÉSUMÉ

L'auteur montre expérimentalement l'effet de la modification de la qualité du rayonnement incident sur la distribution de dose obtenue avec les filtres-en-coin décrits dans un travail précédent. Il décrit une méthode permettant de déduire les courbes isodoses pour un rayonnement incident de CDA donnée quelconque, avec détermination du pourcentage de dose en profondeur sur l'axe central, de la pente des courbes isodoses, de la profondeur des pointes ('noses') d'isodoses à partir d'une qualité de rayonnement de référence unique, ainsi que les coefficients correcteurs pour d'autres qualités. Le pourcentage maximum de dose en surface peut être déduit par une méthode similaire. L'auteur étudie aussi l'effet d'un masque en plomb sur un champ avec coin, de la modification de la DFP de l'applicateur, et de la modification de la position du coin.

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BOOK REVIEWS

BETATRON UND TELECOBALTTHERAPIE. Internationales Symposium am Czerny-Krankenhaus für Strahlenbehandlung der Universität Heidelberg vom 1. bis 3. Juli 1957. Hrsg. von J. Becker und K. E. Scheer. 204 Seiten und 151 Abbildungen. Springer Verlag, Berlin 1958. Preis: DM 39.80.

The editors in the introduction both stress the desirability of physicists, radiation biologists and clinicians meeting frequently to exchange views and experience in order to develop and improve supervoltage therapy. With this in view prominent scientists from a number of institutes were invited to a symposium at Heidelberg in July 1957.

The book is a collection of twenty-six well illustrated papers presented at the symposium by English, French, German, Italian, Swiss and Swedish authors, covering different scientific fields connected with supervoltage therapy.

The major part of the book deals with clinical experience relating to high energy photons or electrons, and includes descriptions of some therapy units and the characteristics of their operation. Treatment series are published on patients treated with units such as the 2 MeV Van de Graff generator, the 4 MeV linear accelerator, 15, 24 and 31 MeV betatrons, a 30 MeV synchrotron and different telecobalt units. Although the time of observation is in many cases very short, all of the authors agree that supervoltage therapy has proved advantageous in many types of treatment, especially when high energy photons are used against deep-seated tumors, e. g. of the bronchi and the bladder, and for electron beam against, inter alia, lymph-node metastases, carcinoma of the vulva and tumors in the head- and neck region.

In the section dealing with the biologic efficiency of high energy radiation, a great number of experiments both with photons and electrons is reported. It is pointed out that the relative biologic efficiency found by different authors (normally in the range 0.4—1.2) depends on many factors such as the biological object and its stage of development, the type and degree of reaction by the object, the radiation dose, and the time of observation.

Dosimetric problems of high energy radiation are considered in the last section. Basic theoretical viewpoints are discussed and practical measuring methods are described for dose distribution studies and absolute measurements. Reports are given on the electron backscatter from various materials and the possibility of electromagnetically focusing 30 MeV electrons and neutron measurements around a 35 MeV betatron.

As a survey of current development within this field the value of the book is increased considerably by the reproduction of several interesting and occasionally animated discussions between the participants in the symposium.

Many readers might have welcomed the inclusion in this valuable collection of a short summary in other languages, at the end of each paper, since within the text itself three different languages are used.

Rune Walstam

THE PNEUMOCONIOSIS PROBLEM WITH EMPHASIS ON THE ROLE OF THE RADIOLOGIST. By Eugene P. Pendergrass. 146 pages, 53 illustrations. Charles C. Thomas, Springfield, Ill. 1959. Price: $ 6.75.

The title of the book covers its contents, which deal with the pneumoconiosis problem from every conceivable roentgenologic standpoint. Because of his wide experience and critical attitude towards all over-diagnosis the author gives an excellent presentation of the radiologist's possibilities for diagnosing pneumoconiosis in the lungs. Although the majority of the various types of pneumoconiosis are treated, the description and discussion of silicosis occupies, quite naturally, the major part of the book. A short review can give no adequate description of this comprehensive treatise; all radiologists interested in pneumoconiosis are therefore advised to read the book. The classification of the different stages of silicosis which the author has used since 1935 is largely the same as that previously suggested by Reichmann. It is completely in accord with the reviewer's own experience and would seem to be the best, as well as the only one suitable for international use. When the author writes that his classification 'is very similar in many respects to the one described by Fletcher et al.', this must surely be regarded as a sign of an agreeable willingness to cooperate internationally. At the Third International Conference of Experts on Pneumoconiosis, Fletcher's classification was recommended for international use, but this classification, which is very detailed, can in point of fact be used only in anthracosis, not generally. It diverges on many essential points from that used by the author.

In asbestosis, the schema used in silicosis can not be used. The author stresses the diagnostic significance of the pleural reaction. Asbestosis can not be diagnosed before thickening of the pleura has been observed; the latter condition arises earliest in the basal portions of the lungs.

Gunnar Jönsson

QUANTITIES, UNITS AND MEASURING METHODS OF IONIZING RADIATION. Editor: Franco Fossati. Ulrico Hoepli, Milan 1959. 359 pages, 126 illustrations, 20 tables. Price: 3 500 lire.

The above publication contains the collected papers and discussions delivered at a Symposium held in Rome, in April 1958. The Symposium was organised by the Italian Society of Medical Radiology and Nuclear Medicine and the Superior Institute for Health, in collaboration with the World Health Organisation and the "Comitato Nazionale per le Ricerche Nucleari". The number of papers published amounts to twenty-four, all in the English language; some of the discussions are in French, German or Italian, however, i. e. in the respective languages of the contributors.

E. Lindgren

TUBERCULOSIS IN WHITE AND NEGRO CHILDREN. Volume I. The roentgenologic aspects of the Harriet Lane Study. By Janet B. Hardy. 122 pages, 82 illustrations. $ 7.50. Volume II. The epidemiologic aspects of the Harriet Lane Study. By Miriam E. Brailey. 103 pages, 8 graphs and 39 tables. $ 4.50. Harvard University Press, Cambridge, Mass., 1958.

The two volumes give an account of experiences gained at the Harriet Lane Tuberculosis Clinic at Baltimore between 1928 and 1944. During that period, 437 white and 892 negro children were examined. It was established that the prognosis is poorer for negro than for white children. This finding does not surprise the reviewer, seeing that the Clinic is for out-patients and hence that the hygienic conditions were different for the two groups studied, although the authors state that the difference in this respect was not striking.

The first volume contains a large number of roentgenograms, chiefly of the lungs in different stages of child tuberculosis, accompanied by a brief clinical report on each case. In the reviewer's opinion, it would have been more advantageous to present few pictures and then of better quality. The introductory chapter deals with anatomy and the "interpretation" of roentgenograms of the thorax. The last chapter is devoted to bronchographic technique. Local anaesthesia seems to be used for bronchoscopy and bronchography in children to a far greater extent than in Sweden.

Volume II, which discusses the prognosis in primary tuberculosis and the risk of progressive pulmonary tuberculosis in the event of reinfection, may possibly be of value to readers particularly interested in juvenile tuberculosis and statistics.

Uno A. T. Norlin

ADVANCES IN BIOLOGICAL AND MEDICAL PHYSICS. Volyme VI. Academic Press Inc, New York 1958. 639 pages, 172 illustrations, 27 tables. Price: 16.50 dollars.

Books of this kind do not easily lend themselves to a critical review in the conventional way. The volume has been edited by Cornelius A. Tobias and John H. Lawrence of the University of California, Berkeley. It contains authoritative papers, contributed from the United States, England, France, Denmark and Sweden, on a number of subjects that should be of interest to both general and specializing radiologists and to therapeutic centres. The contents are as follows:

Ion and water transport in stomach and intestine; Artificial and induced periodicity in living cells; Radiobiological aspects of the induction of lysogenic bacteria to produce phage with X-ray, gamma ray and ultraviolet radiations; Cell studies with microspectrography; Some aspects of the effect of ionizing radiation on tumors in experimental animals; Fallout from nuclear weapons tests; Radiological contrast enhancing methods; Quantitative measurement of regional circulation in the central nervous system by the use of radioactive inert gas; Intense ultrasound in investigations of the central nervous system; Isotopic tracers in the study of diabetes; Application of light scattering to biological systems deoxyribonucleic acid and the muscle proteins; Physical and chemical mechanisms in the injury of cells by ionizing radiations.

E. Lindgren

PROTECTION IN DIAGNOSTIC RADIOLOGY. Ed. by B. P. Sonnenblick. 346 pages, 44 illustrations and 88 tables. Rutgers University Press, New Brunswick, N. J., 1959. $ 7.50.

This is a kind of anthology and contains reprints of 36 papers from the period 1942 — 1957. The editor is responsible for the preface and introduces the various sections with summaries, commentaries, and additional references. At the end of the book he gives a few main rules for the protection of personnel and patients in diagnostic radiology, a list of certified physicists and other sources of help and information, and a catalogue of published protection recommendations and of papers of interest which could not be reprinted *in extenso*.

The form chosen has the inevitable drawback of repetition, a number of authors having written independently on identical or closely related subjects. Because of the relatively long span of fifteen years, the reader must closely observe the publication date of the separate papers in order not to become confused by the changes in perspectives and protection requirements which have occurred. This is especially important because the communications are not in chronologic order but have been spread somewhat arbitrarily over a number of sections. The papers naturally take no cognizance of the present (1959) recommendations, which are however briefly mentioned by the editor.

The value of a publication such as this is wholly dependent upon a representative selection from the fast-growing literature in the field. The choice is of course largely a matter of personal opinion: a number of papers which might have been included could easily be mentioned but on the whole the reviewer feels that the difficult task has been well done. He would perhaps have excluded the papers by Brucer and Parker as being somewhat irrelevant to the main theme. The communication by Spiers on natural radiation levels is valuable, on the contrary, as a background to the recommendations on maximum permissible doses to whole populations, and the genetic papers provide excellent contributions to a much discussed problem. Most of the remaining papers deal with radiation doses measured in personnel and patients, practical protection measures and supervision, and maximum permissible doses.

A few printing errors have been noted and some of the illustrations are difficult to interpret. On the whole, the book can be recommended to all who are — or should be — interested in radiation protection. It is strongly and repeatedly stressed that roentgen examinations should not be performed indiscriminately without sufficient indications but, conversely, that they should not be omitted when of real value. It is also emphasized that all radiologists should obtain information, now almost always conspicuous by its absence, regarding the radiation output from their tubes; for it is only then that the right balance can be struck between the hazards of carrying out a certain examination and the risks of not doing so.

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KEITH, A.: Human embryology and morphology. 6th edition, p. 523. Arnold & Co, London 1948.

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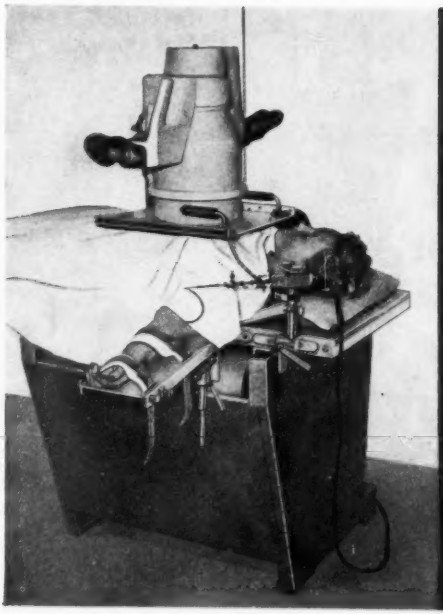

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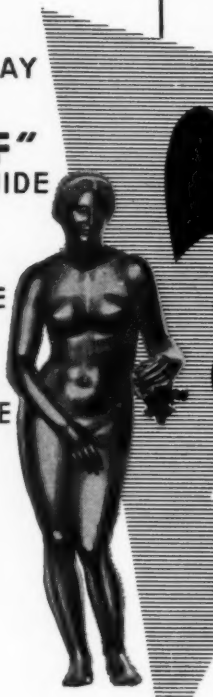

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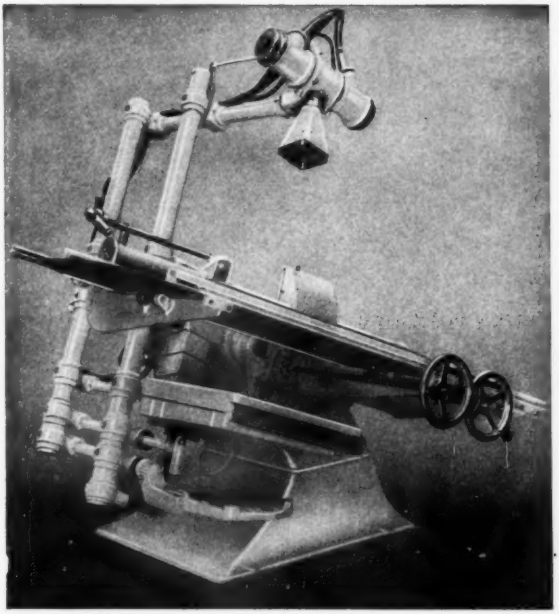

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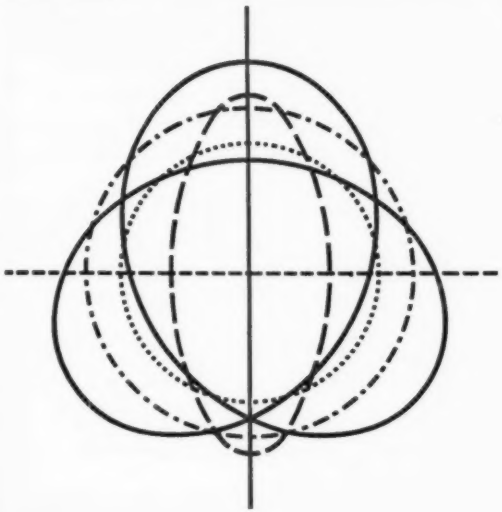

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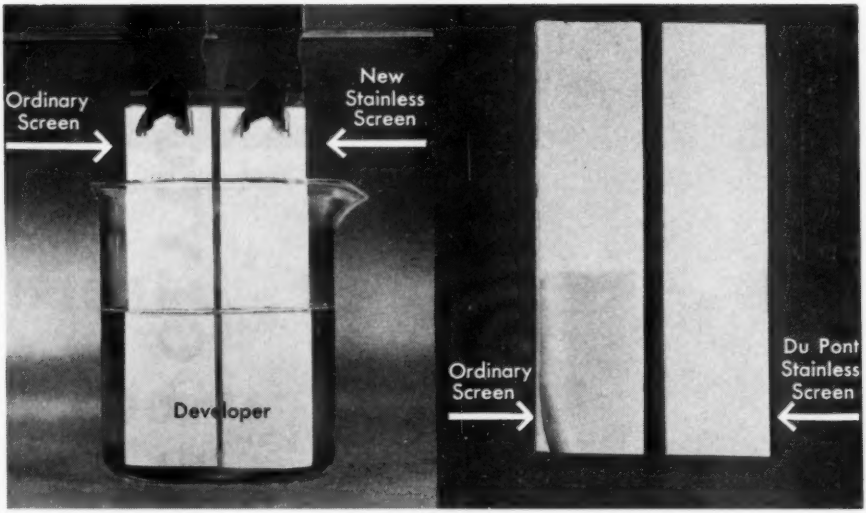

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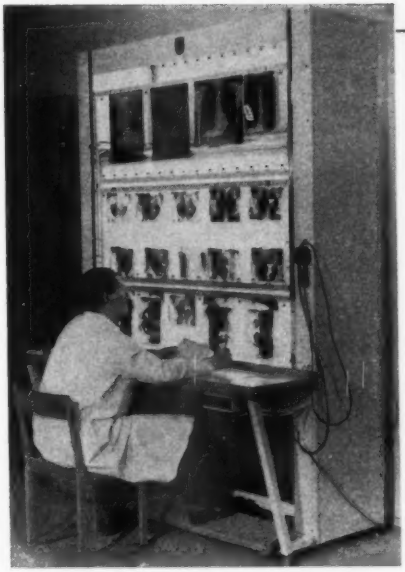

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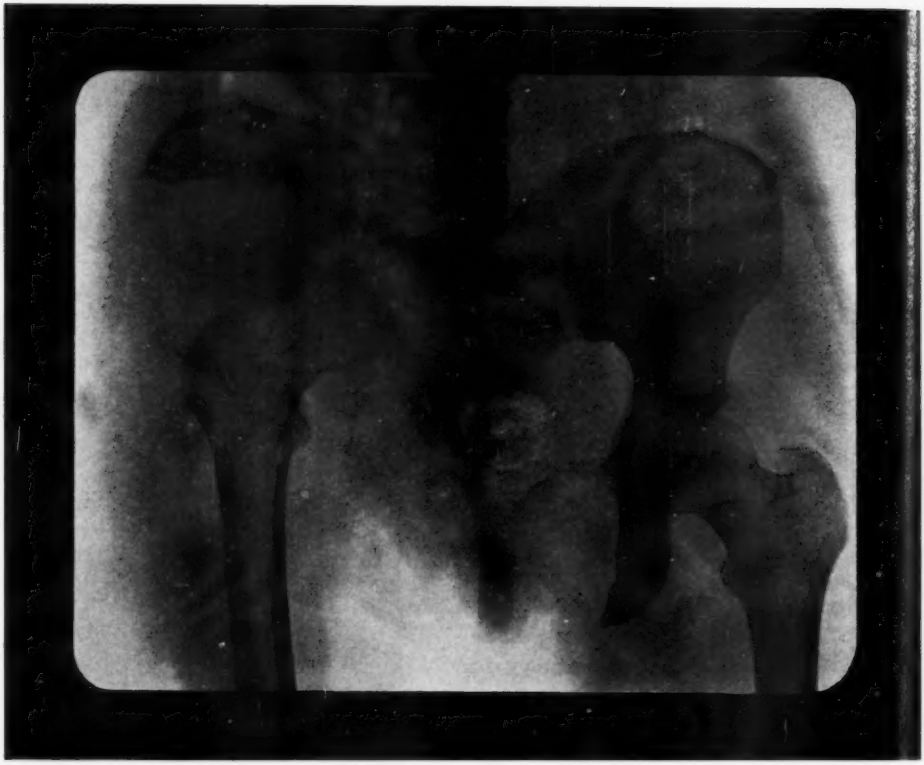

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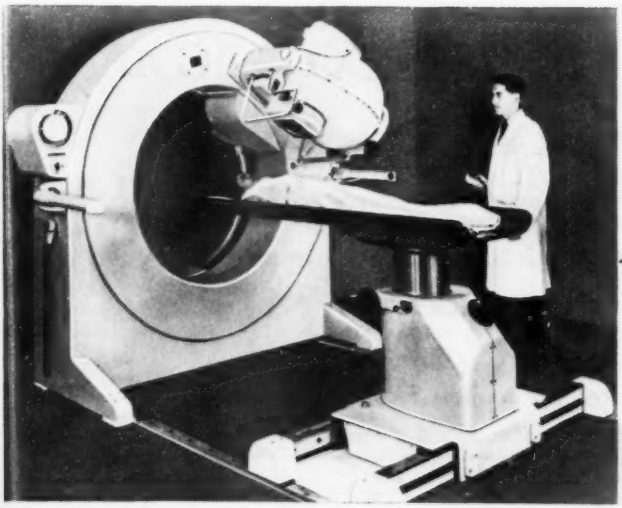

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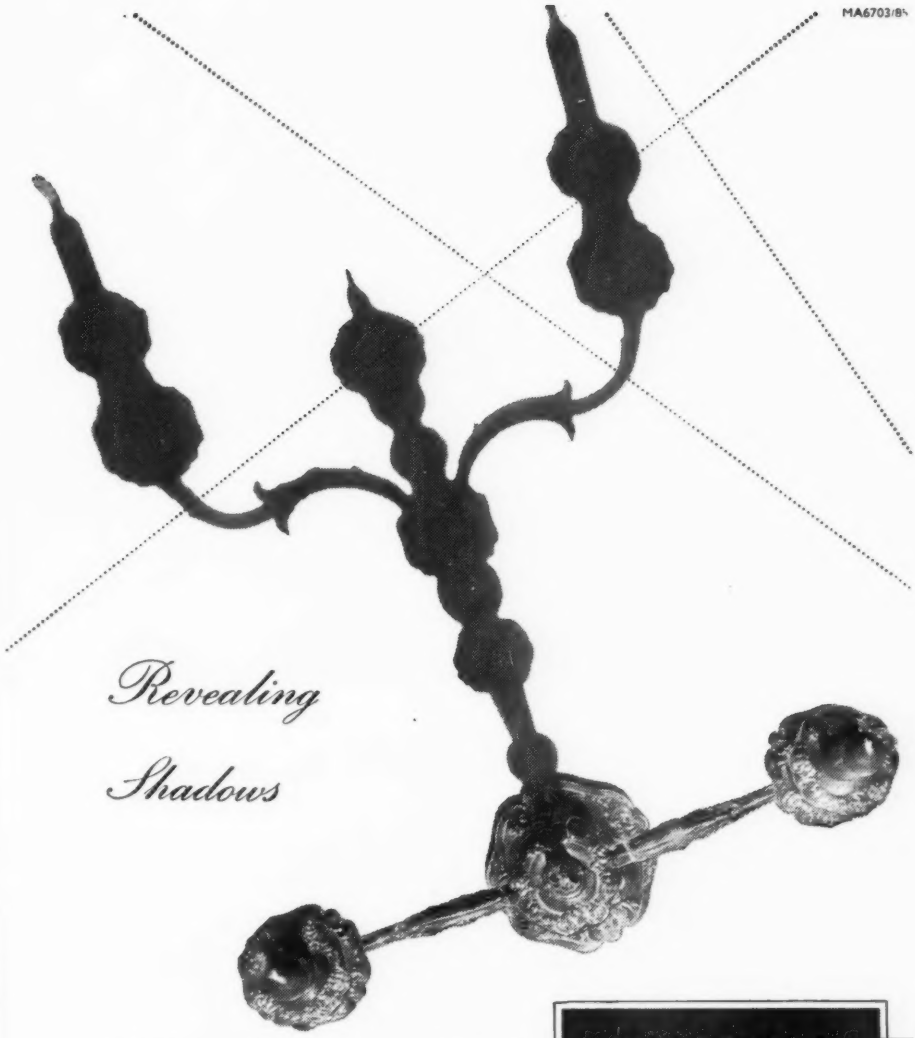

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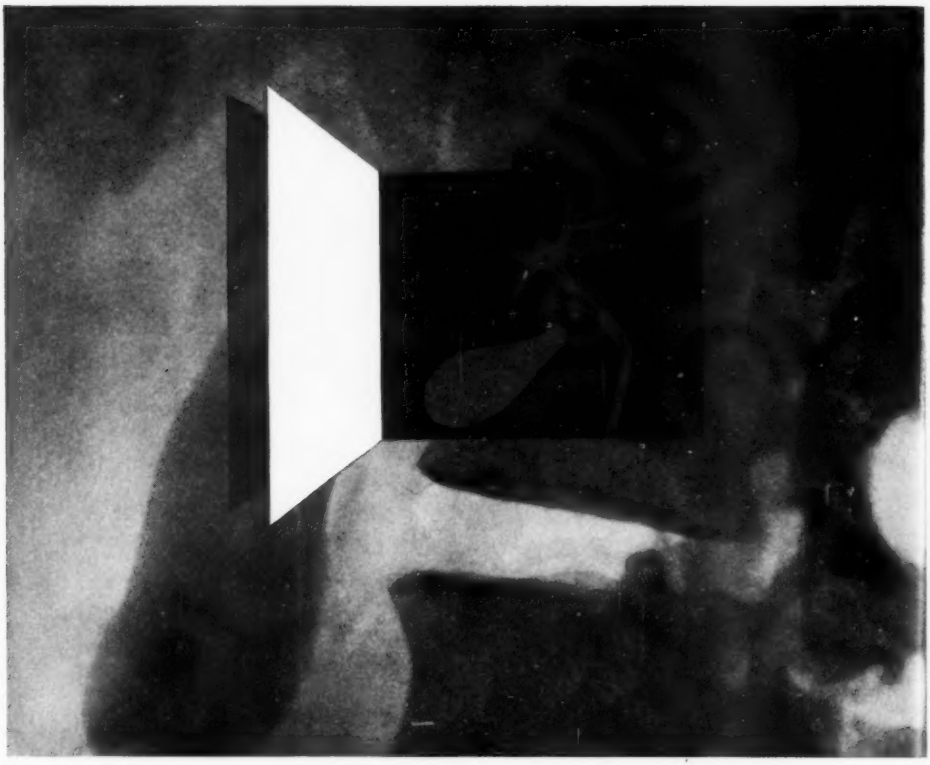

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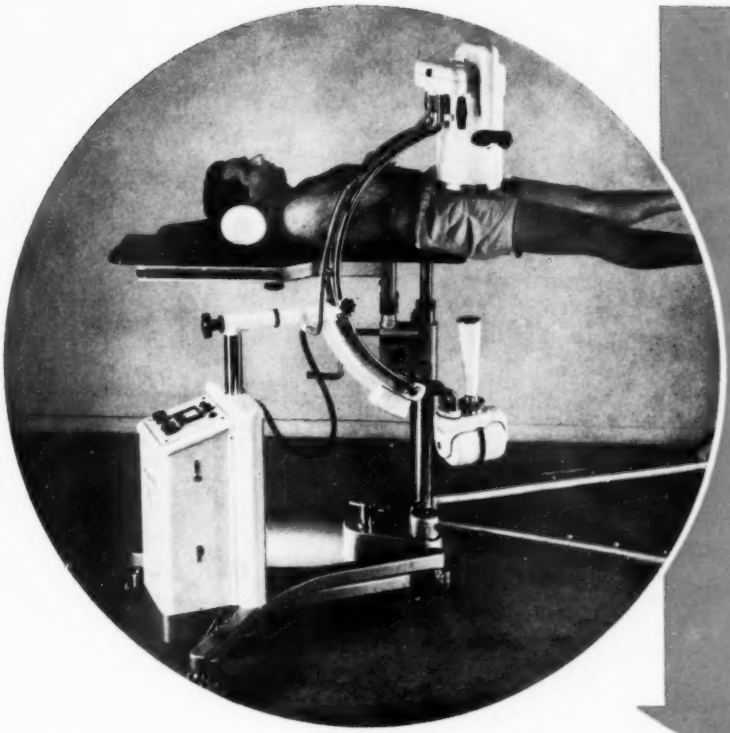

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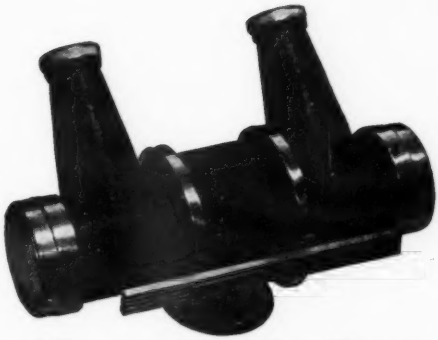

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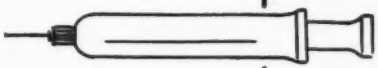

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